



US010982822B2

(12) **United States Patent**  
**Jiang et al.**

(10) **Patent No.:** **US 10,982,822 B2**  
(45) **Date of Patent:** **Apr. 20, 2021**

(54) **LED TUBE LAMP**

(71) Applicant: **JIAXING SUPER LIGHTING ELECTRIC APPLIANCE CO., LTD,**  
Jiaxing (CN)

(72) Inventors: **Tao Jiang,** Jiaxing (CN); **Ming-bin Wang,** Jiaxing (CN); **Jun-Ren Chen,** Jiaxing (CN); **Ai-Ming Xiong,** Jiaxing (CN); **Feng Zou,** Jiaxing (CN); **Wei-Hong Xu,** Jiaxing (CN); **Jian Lu,** Jiaxing (CN); **Guang-Dong Wang,** Jiaxing (CN)

(73) Assignee: **JIAXING SUPER LIGHTING ELECTRIC APPLIANCE CO., LTD,**  
Jiaxing (CN)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/920,422**

(22) Filed: **Jul. 3, 2020**

(65) **Prior Publication Data**  
US 2020/0332965 A1 Oct. 22, 2020

**Related U.S. Application Data**  
(63) Continuation of application No. 16/731,342, filed on Dec. 31, 2019, now Pat. No. 10,823,342.

(30) **Foreign Application Priority Data**  
Jan. 2, 2019 (CN) ..... 201910001656.8  
Feb. 28, 2019 (CN) ..... 201910152736.3  
(Continued)

(51) **Int. Cl.**  
**F21K 9/278** (2016.01)  
**H05K 1/18** (2006.01)

**F21V 15/015** (2006.01)  
**F21V 23/02** (2006.01)  
**F21Y 115/10** (2016.01)  
**F21Y 103/10** (2016.01)  
(52) **U.S. Cl.**  
CPC ..... **F21K 9/278** (2016.08); **F21V 15/015** (2013.01); **F21V 23/02** (2013.01); **H05K 1/181** (2013.01);  
(Continued)

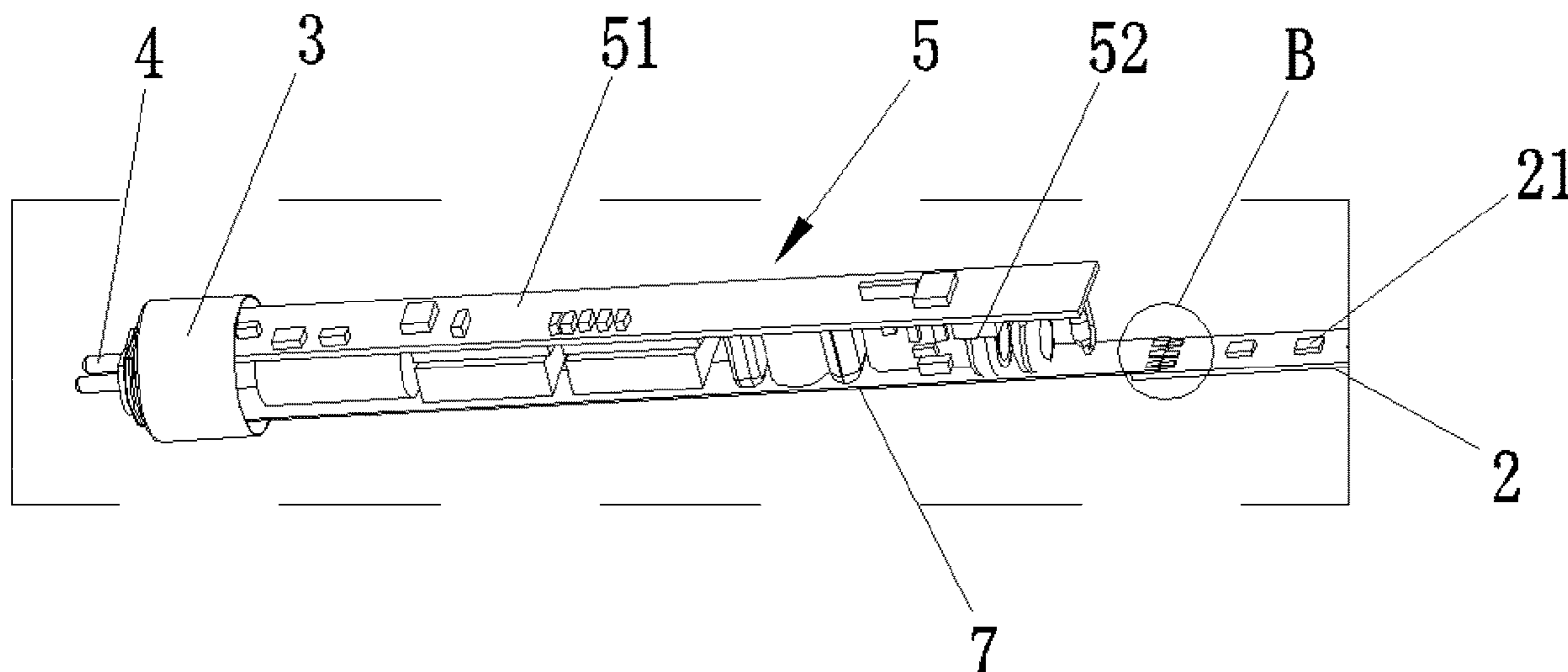
(58) **Field of Classification Search**  
CPC ..... **F21K 9/27-278**; **F21V 15/015**; **F21V 23/0003-026**  
See application file for complete search history.

(56) **References Cited**  
**U.S. PATENT DOCUMENTS**  
9,303,860 B1 ‡ 4/2016 Madireddi ..... F21V 31/005  
2008/0055894 A1 ‡ 3/2008 Deng ..... F21K 9/27  
362/217.05  
(Continued)

**FOREIGN PATENT DOCUMENTS**  
CN 205491290 U 8/2016  
*Primary Examiner* — Mariceli Santiago  
(74) *Attorney, Agent, or Firm* — Simon Kuang Lu

(57) **ABSTRACT**  
An LED tube lamp, comprising: a lamp tube; a first circuit board, disposed in the lamp tube, having a plurality of light sources mounted thereon; two lamp caps disposed at respective ends of the lamp tube; a power supply substantially disposed in one or both of the two lamp caps, the power supply having a second circuit board; and a connection structure having a third circuit board, the third circuit board for connecting the first circuit board to the second circuit board thereby connecting the light sources to the power supply.

**20 Claims, 15 Drawing Sheets**



(30) **Foreign Application Priority Data**  
 Jun. 12, 2019 (CN) ..... 201910506394.0  
 Jun. 14, 2019 (CN) ..... 201910516229.3  
 Nov. 27, 2019 (CN) ..... 201911179027.0

(52) **U.S. Cl.**  
 CPC ..... *F21Y 2103/10* (2016.08); *F21Y 2115/10*  
 (2016.08); *H05K 2201/10106* (2013.01); *H05K*  
*2201/10522* (2013.01)

(56) **References Cited**  
 U.S. PATENT DOCUMENTS

2010/0124054 A1\* 5/2010 Chen ..... F21K 9/278  
 362/221

2010/0201269 A1\* 8/2010 Tzou ..... F21K 9/278  
 315/51  
 2011/0141723 A1‡ 6/2011 Lai ..... F21K 9/272  
 362/218  
 2012/0293991 A1‡ 11/2012 Lin ..... F21K 9/272  
 362/225  
 2013/0223053 A1\* 8/2013 Liu ..... F21V 23/006  
 362/217.17  
 2014/0340884 A1\* 11/2014 Hsia ..... F21V 23/009  
 362/221  
 2016/0091148 A1\* 3/2016 Leung ..... H05B 47/19  
 362/222  
 2016/0091156 A1‡ 3/2016 Li ..... F21V 23/002  
 362/221  
 2016/0215936 A1‡ 7/2016 Jiang ..... F21V 29/508  
 2016/0348851 A1‡ 12/2016 Amrine, Jr. .... F21V 23/06  
 2019/0063690 A1\* 2/2019 Eckert ..... F21K 9/235

\* cited by examiner  
 ‡ imported from a related application

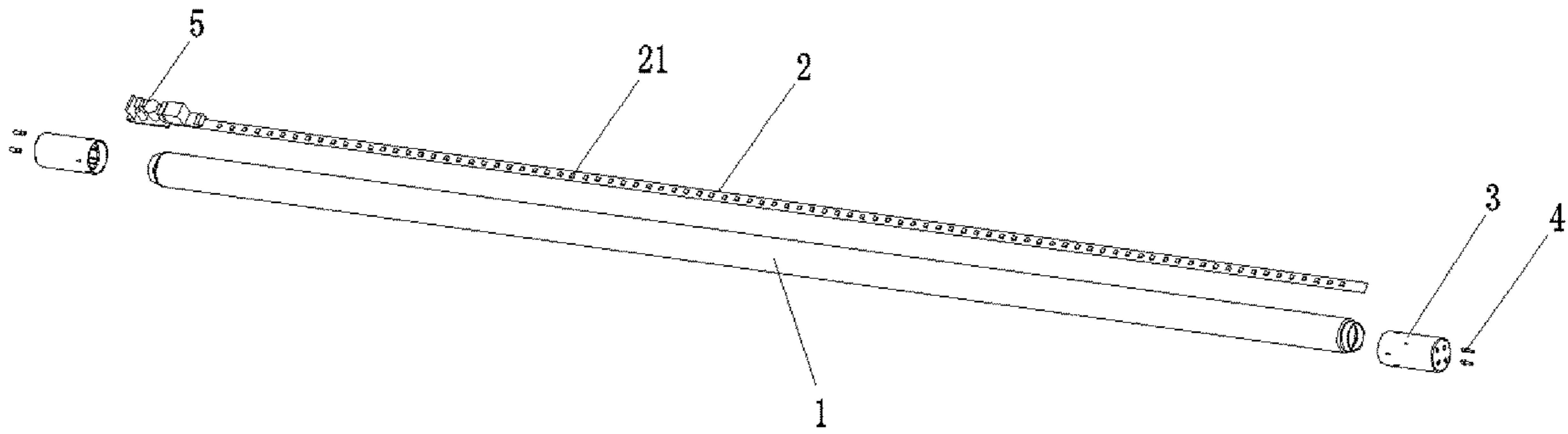


FIG. 1

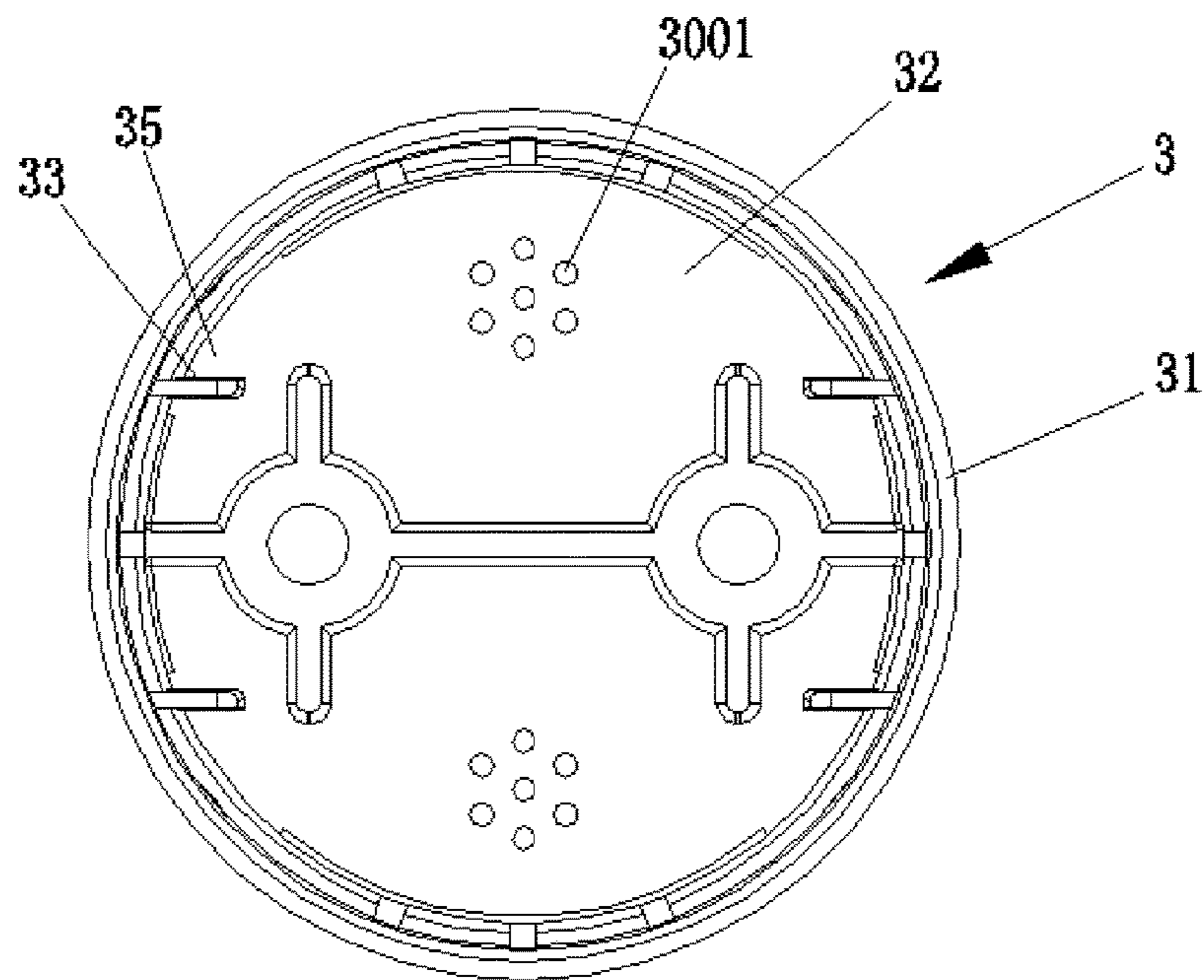


FIG. 2

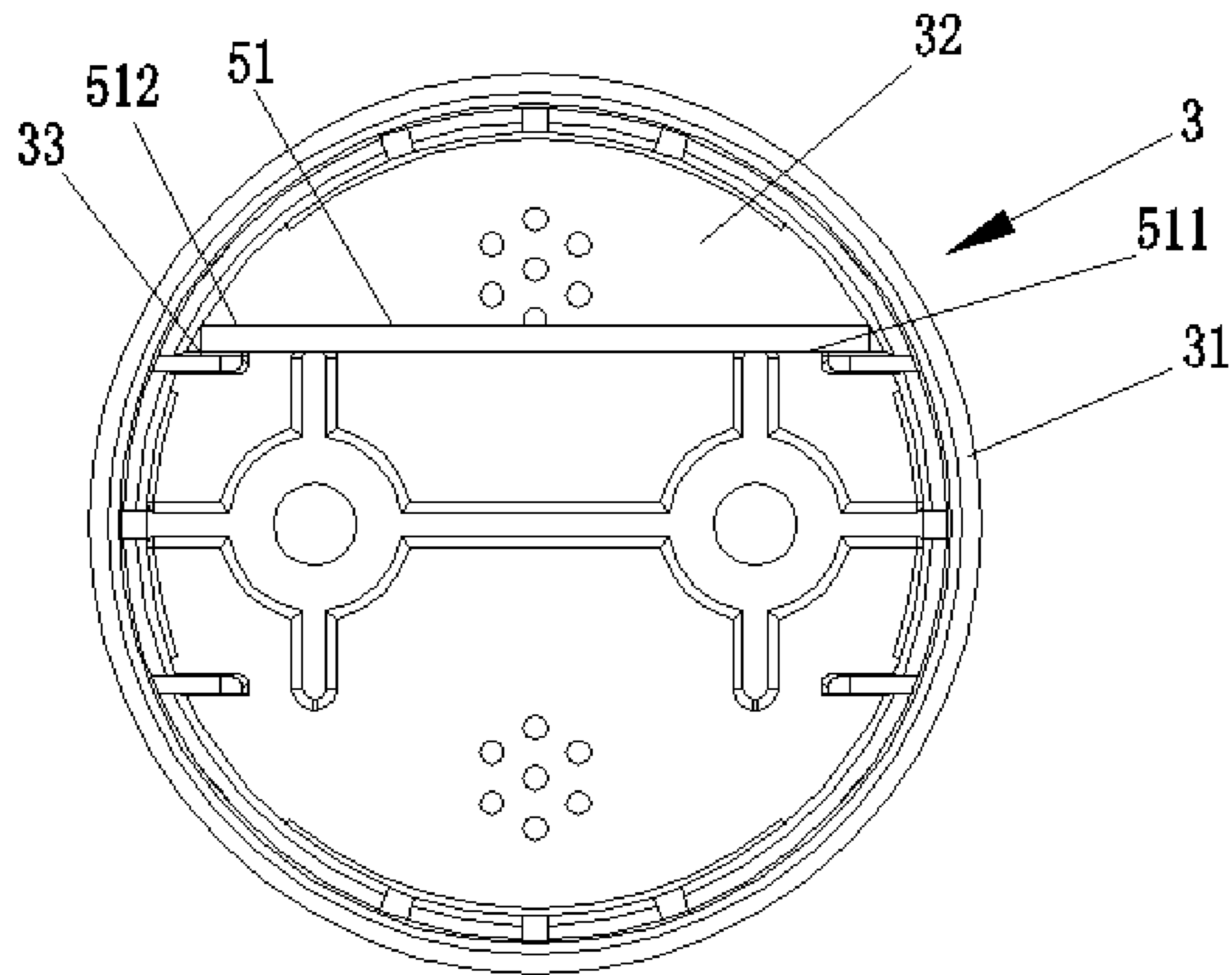


FIG. 3

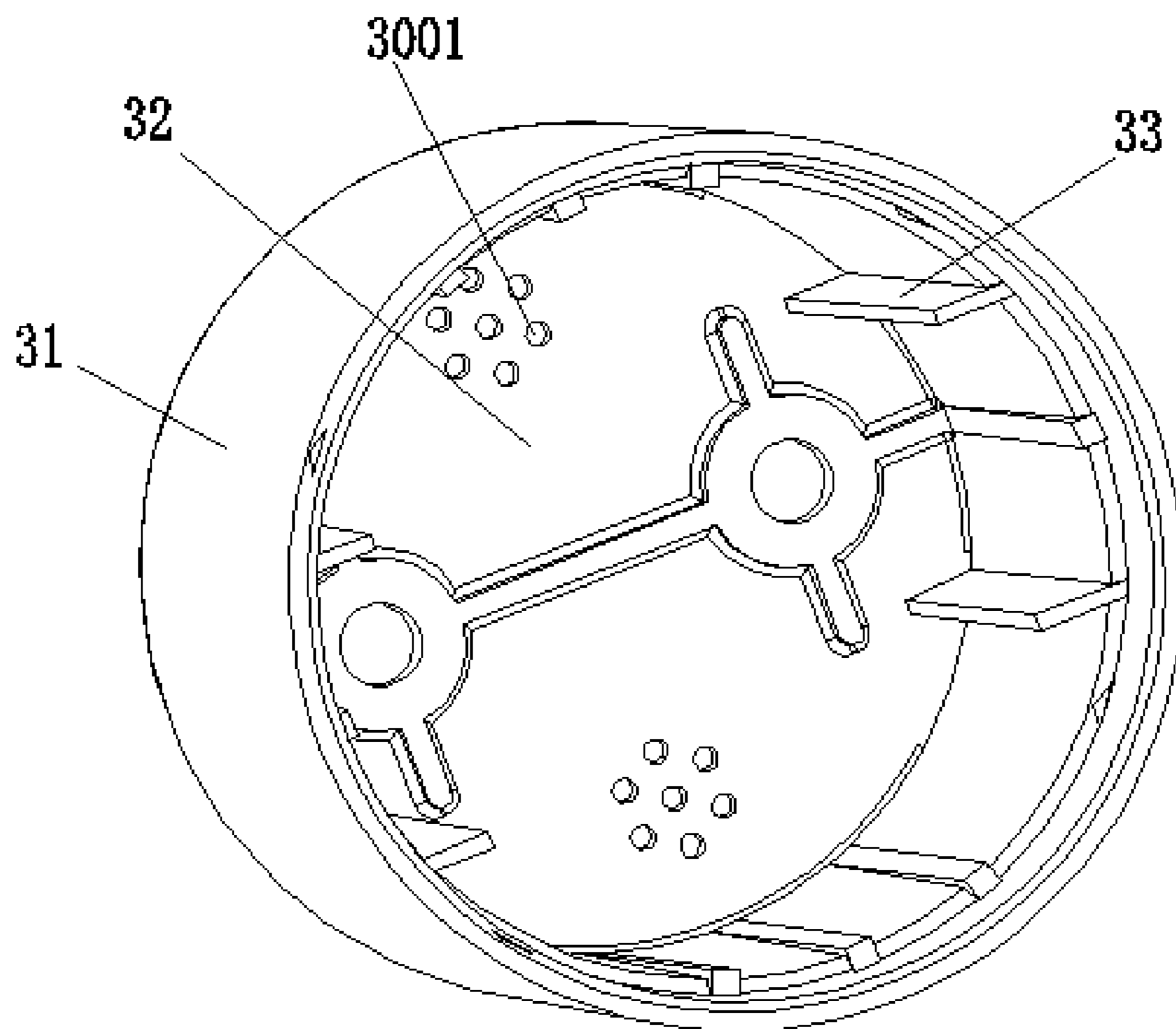


FIG. 4

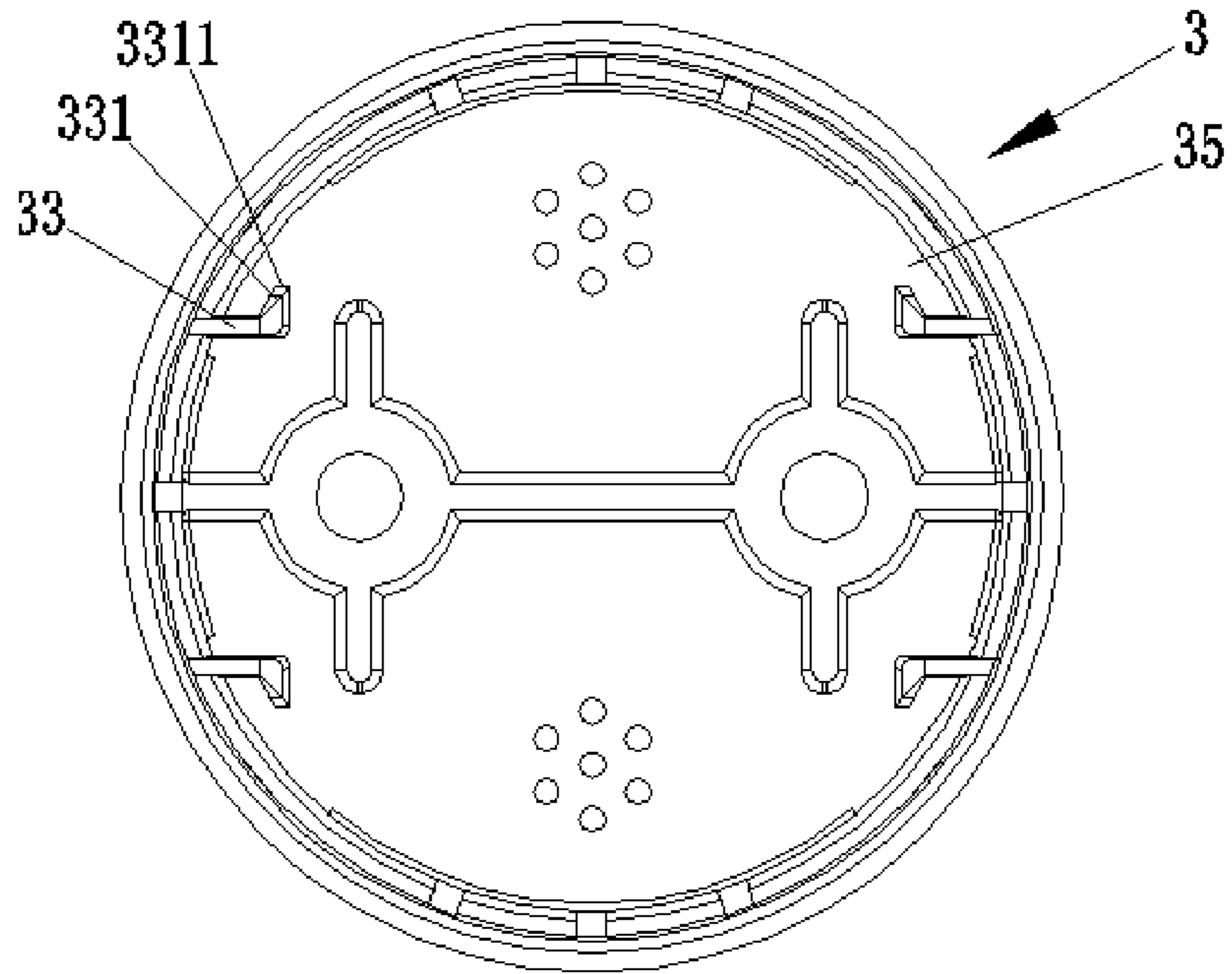


FIG. 5

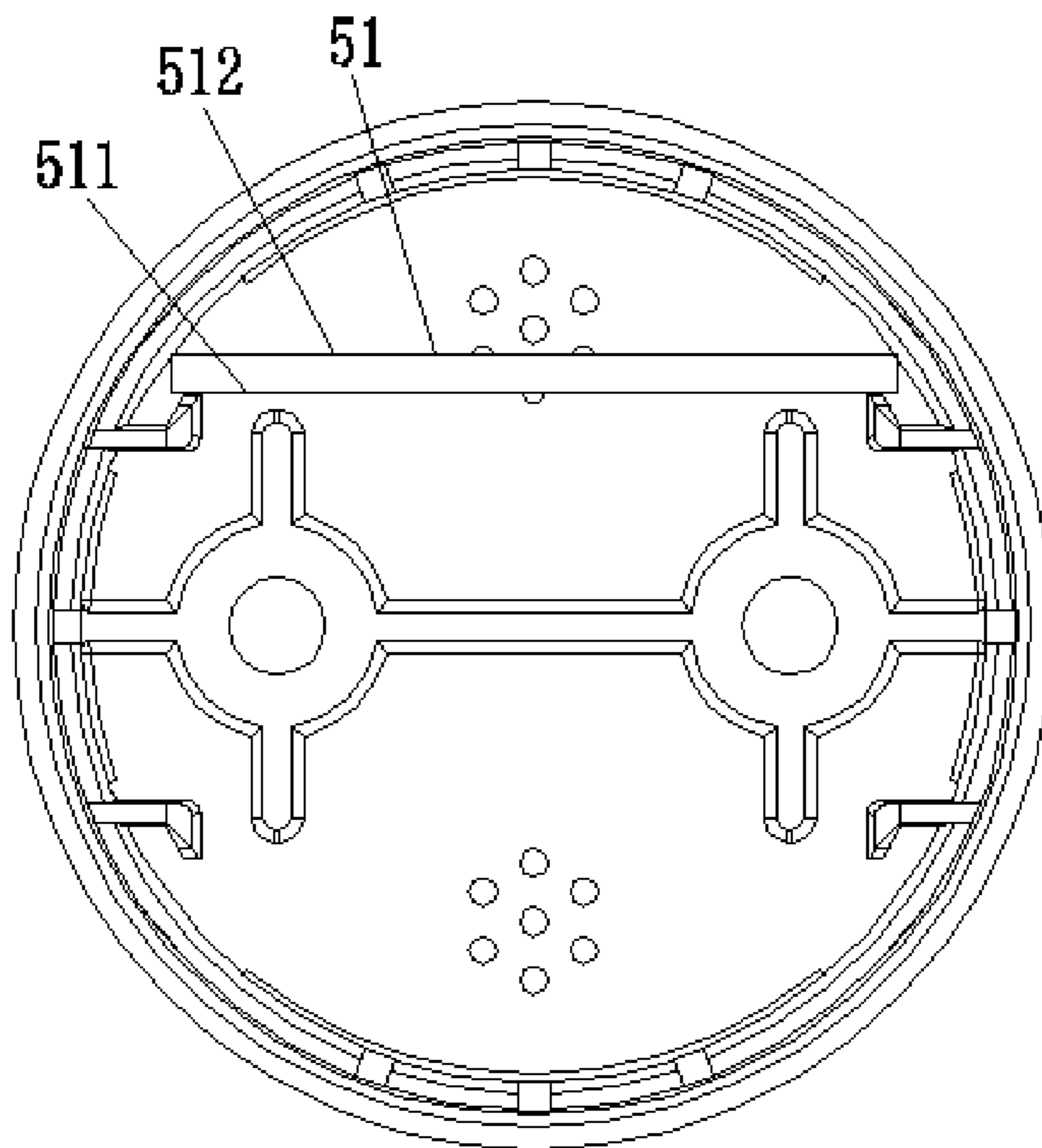


FIG. 6



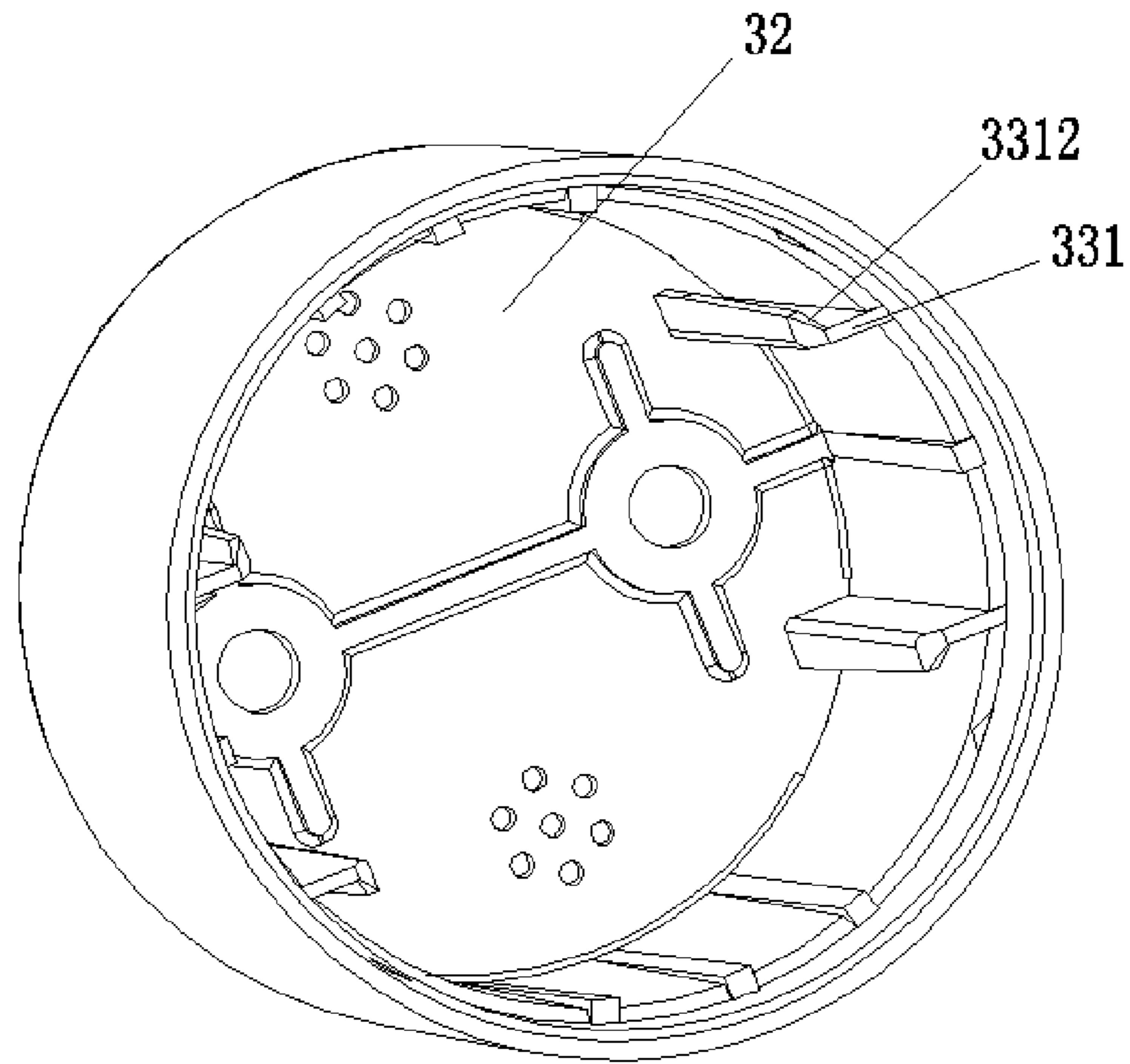


FIG. 7

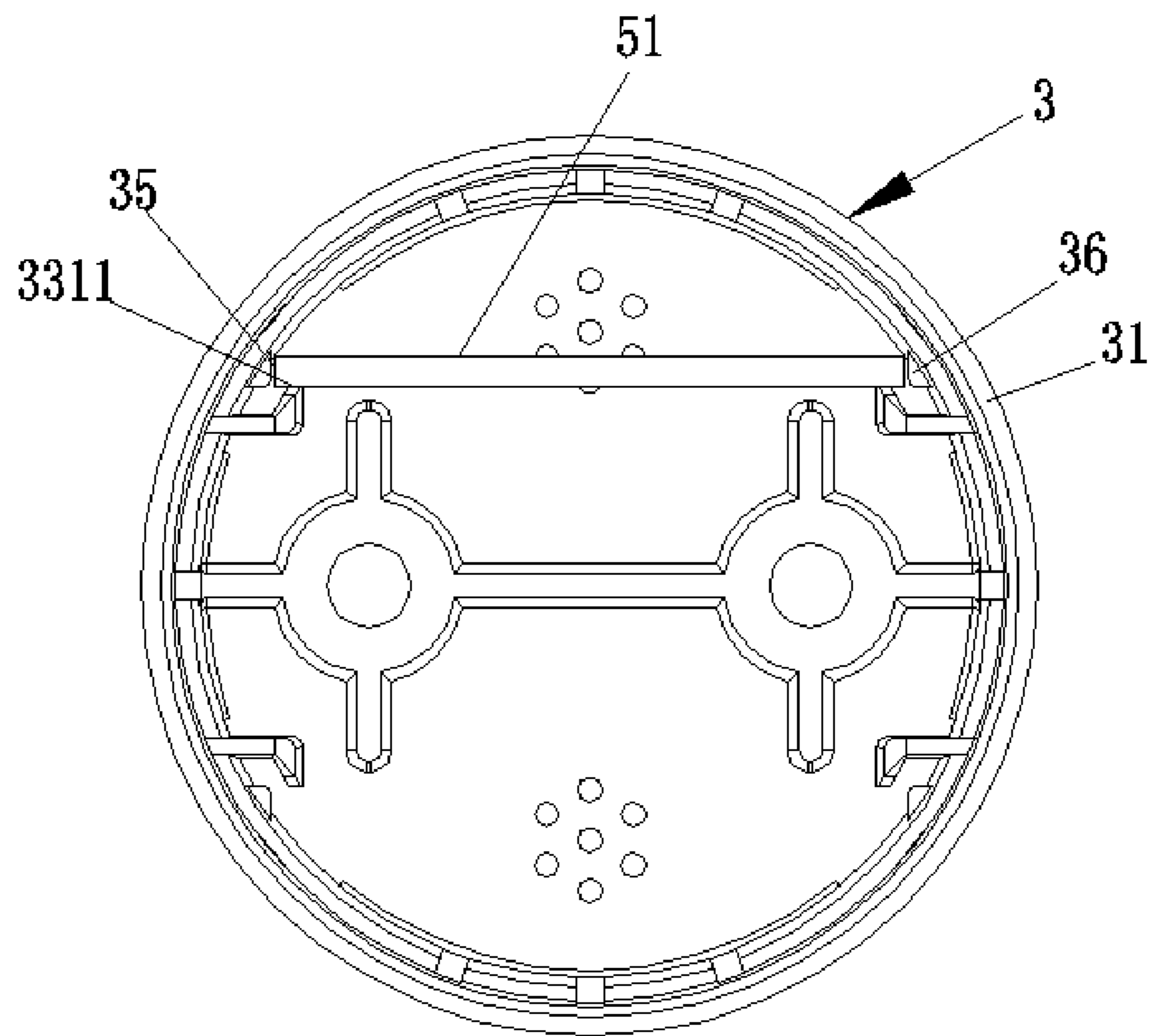


FIG. 8

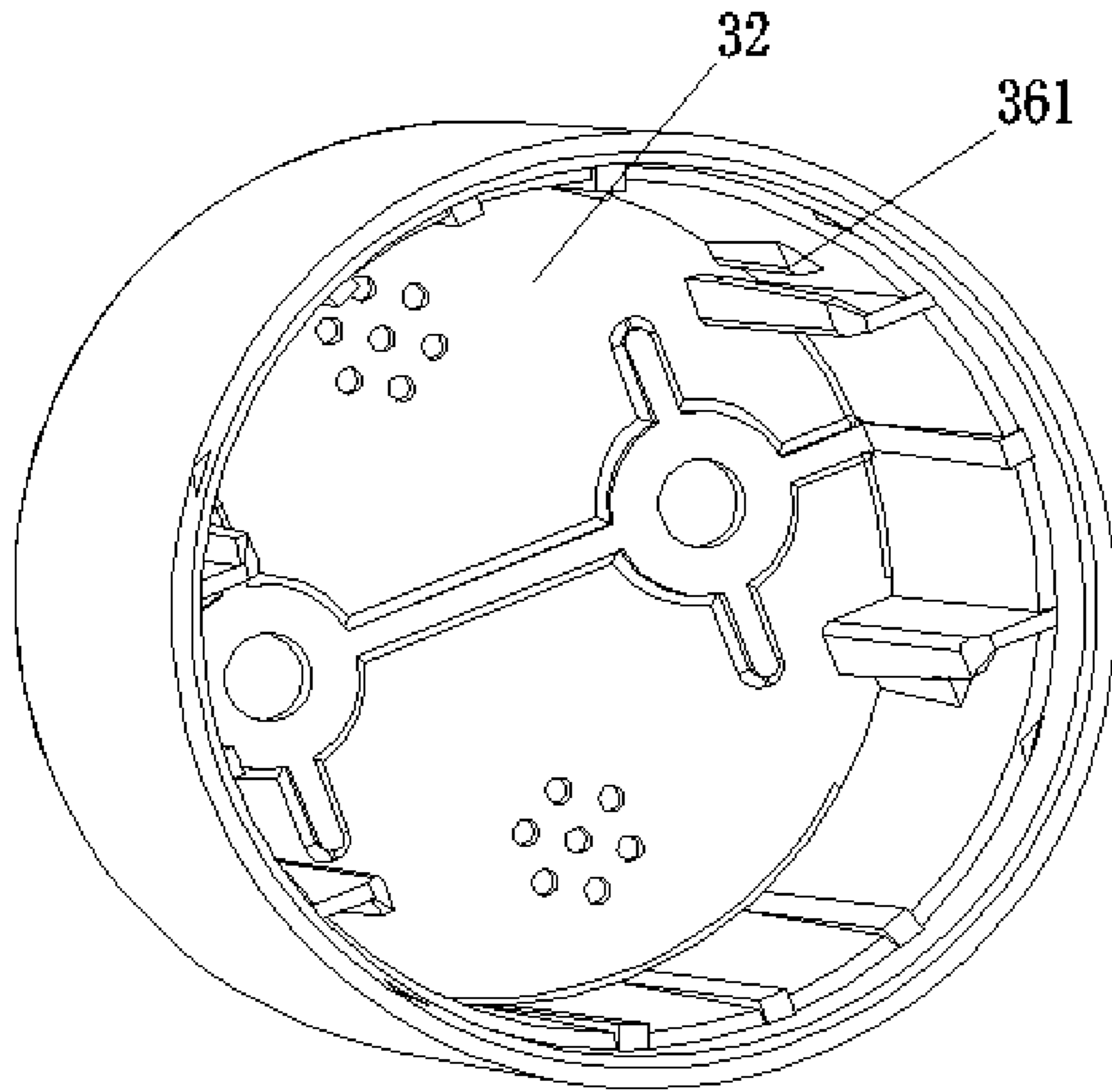


FIG. 9

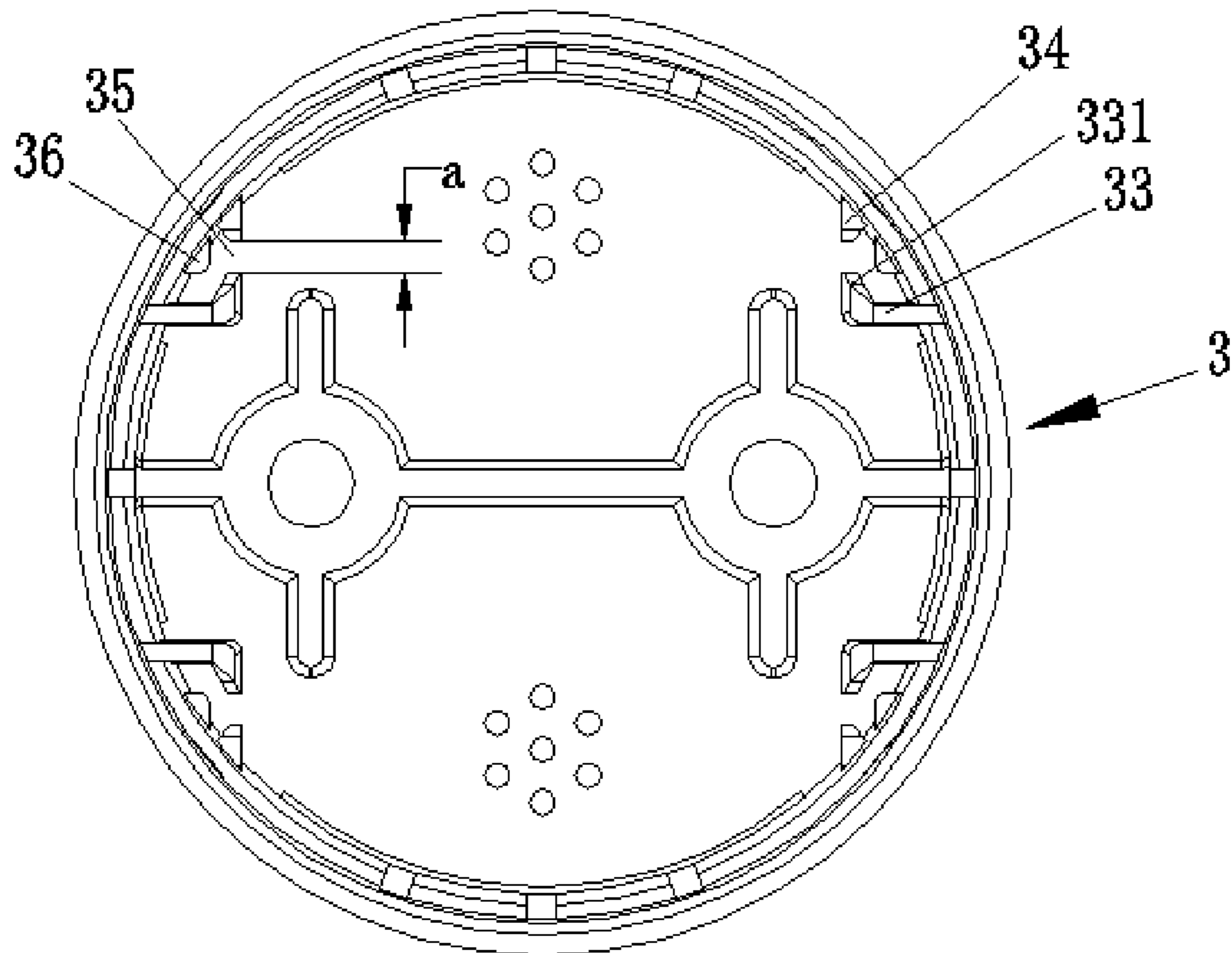


FIG. 10

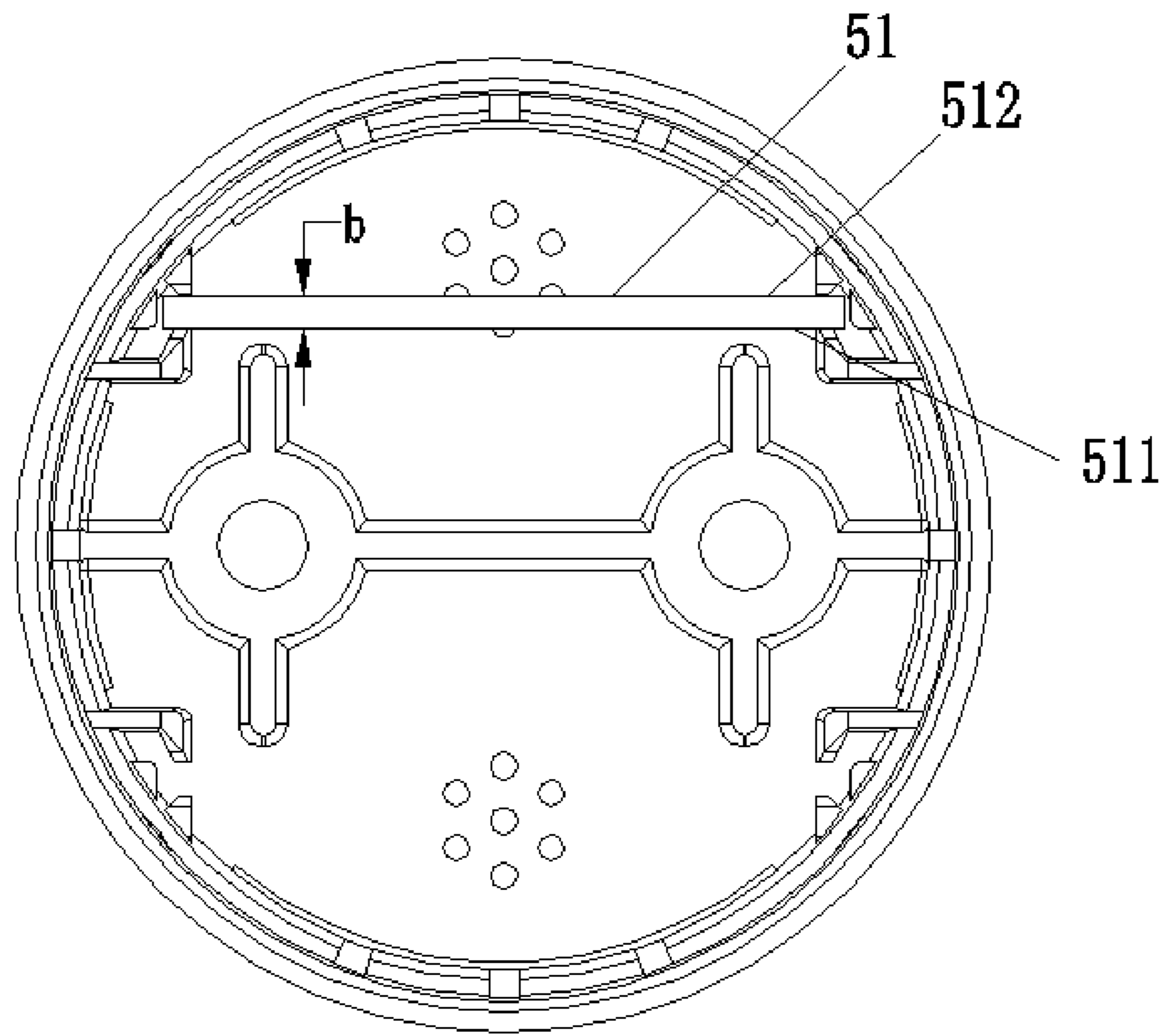


FIG. 11

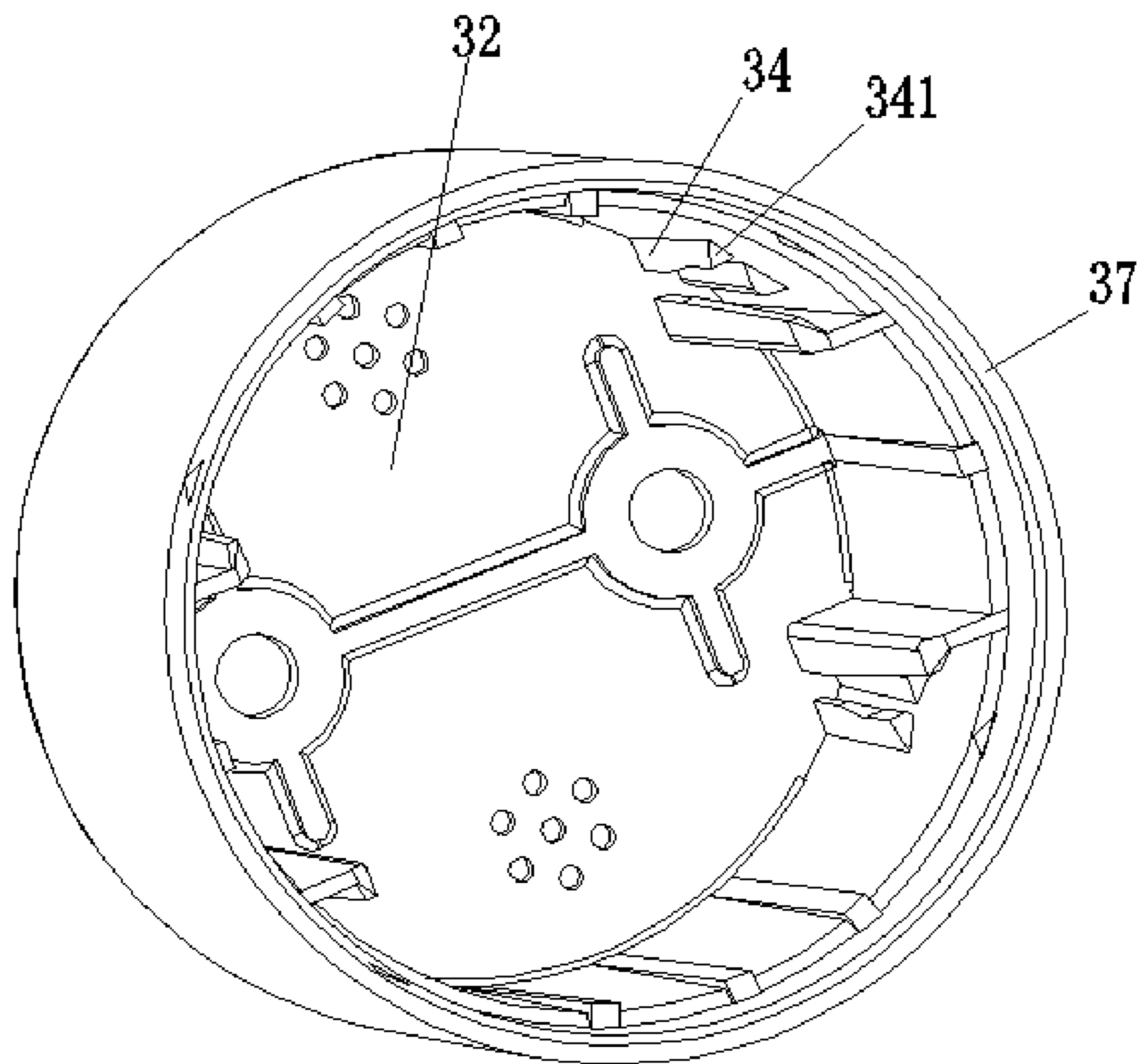


FIG. 12



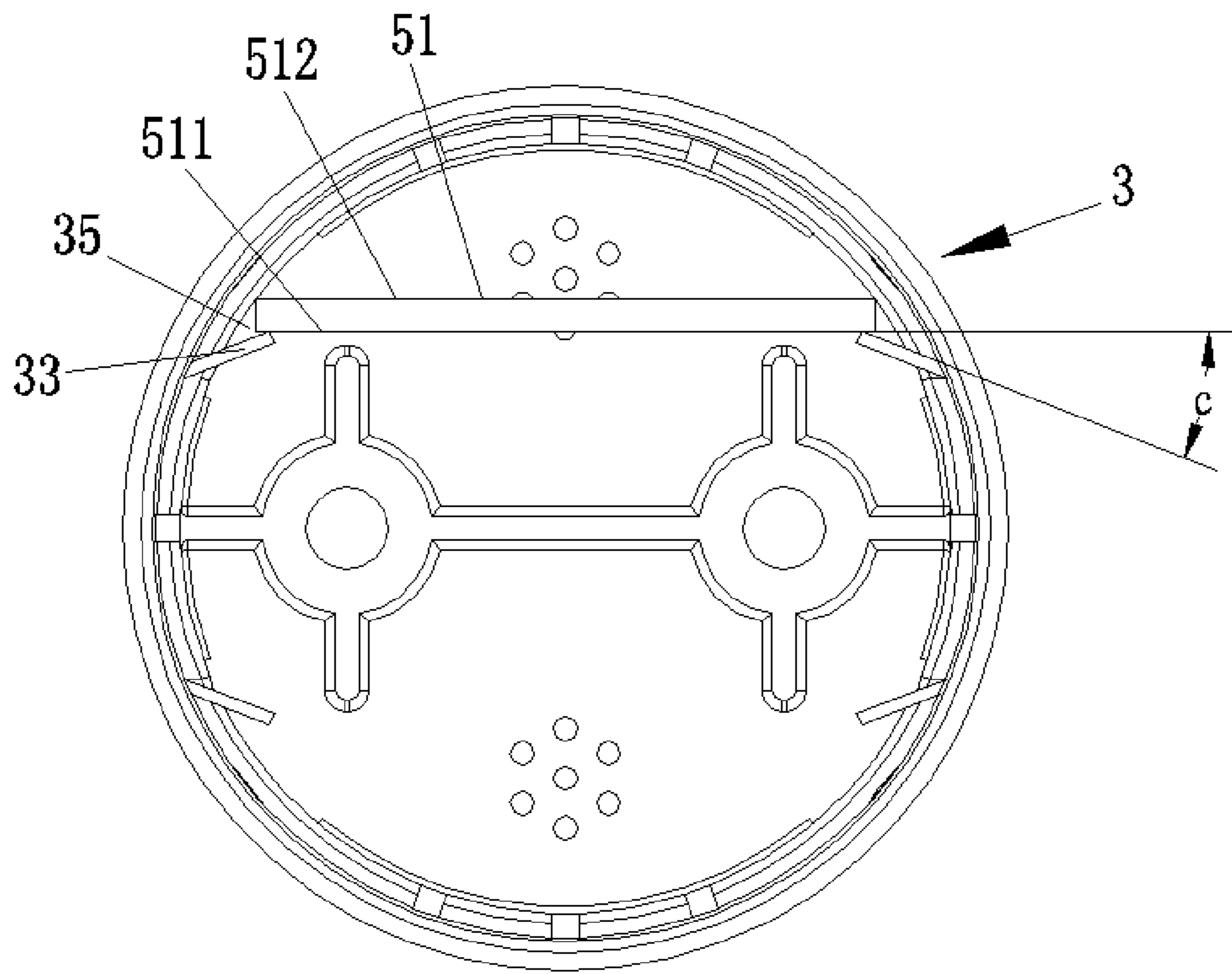


FIG. 13

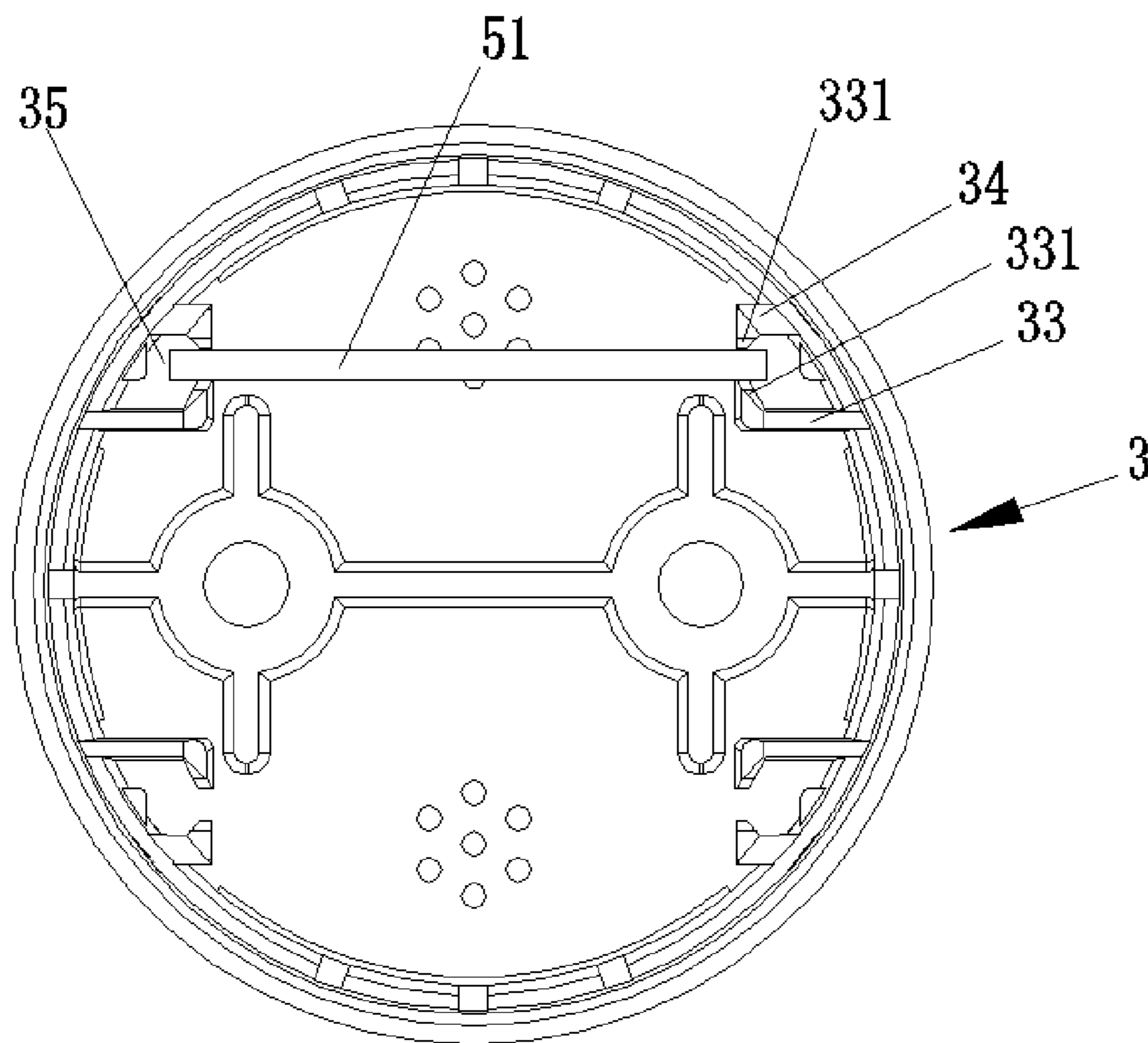


FIG. 14

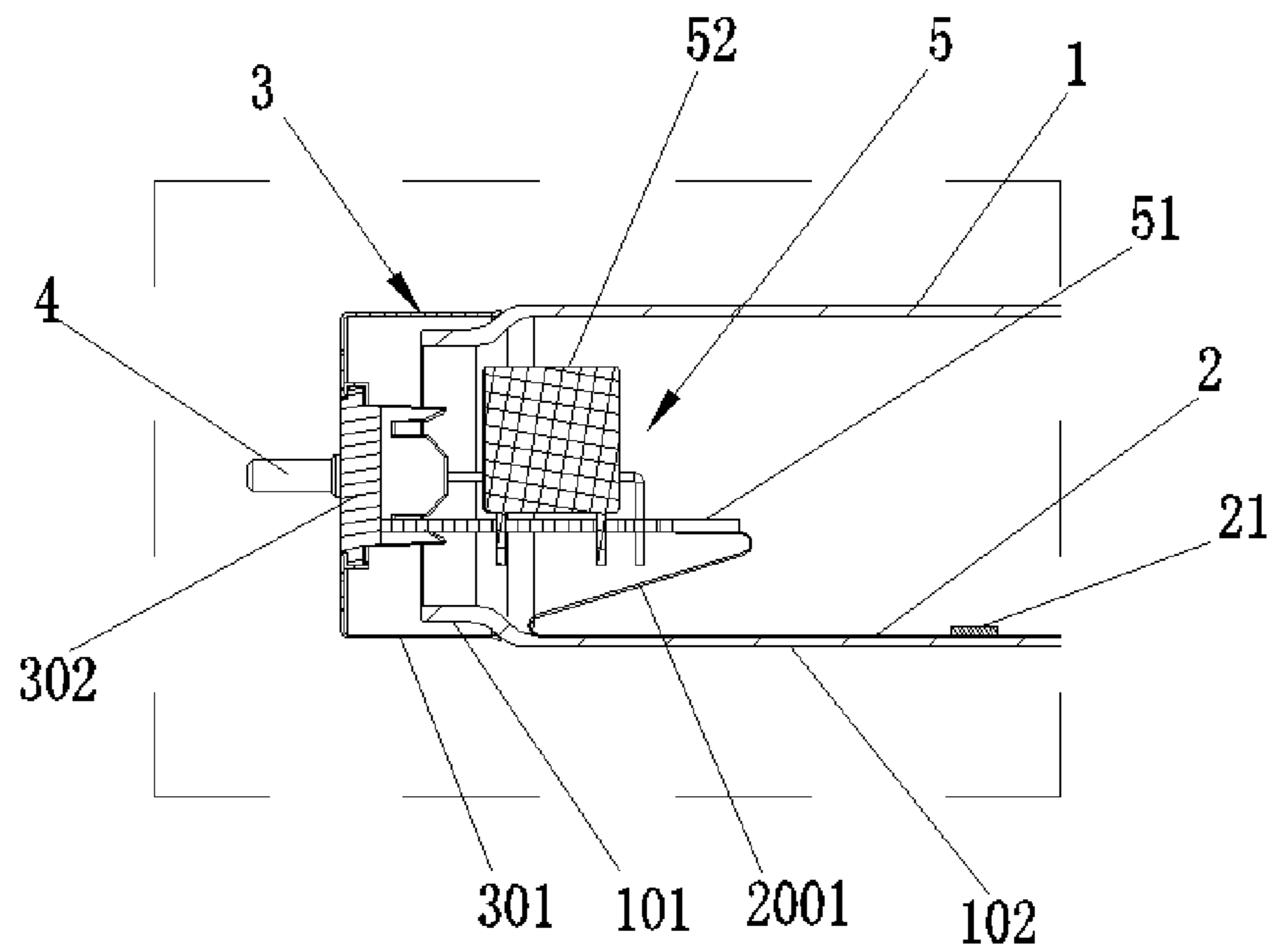


FIG. 15

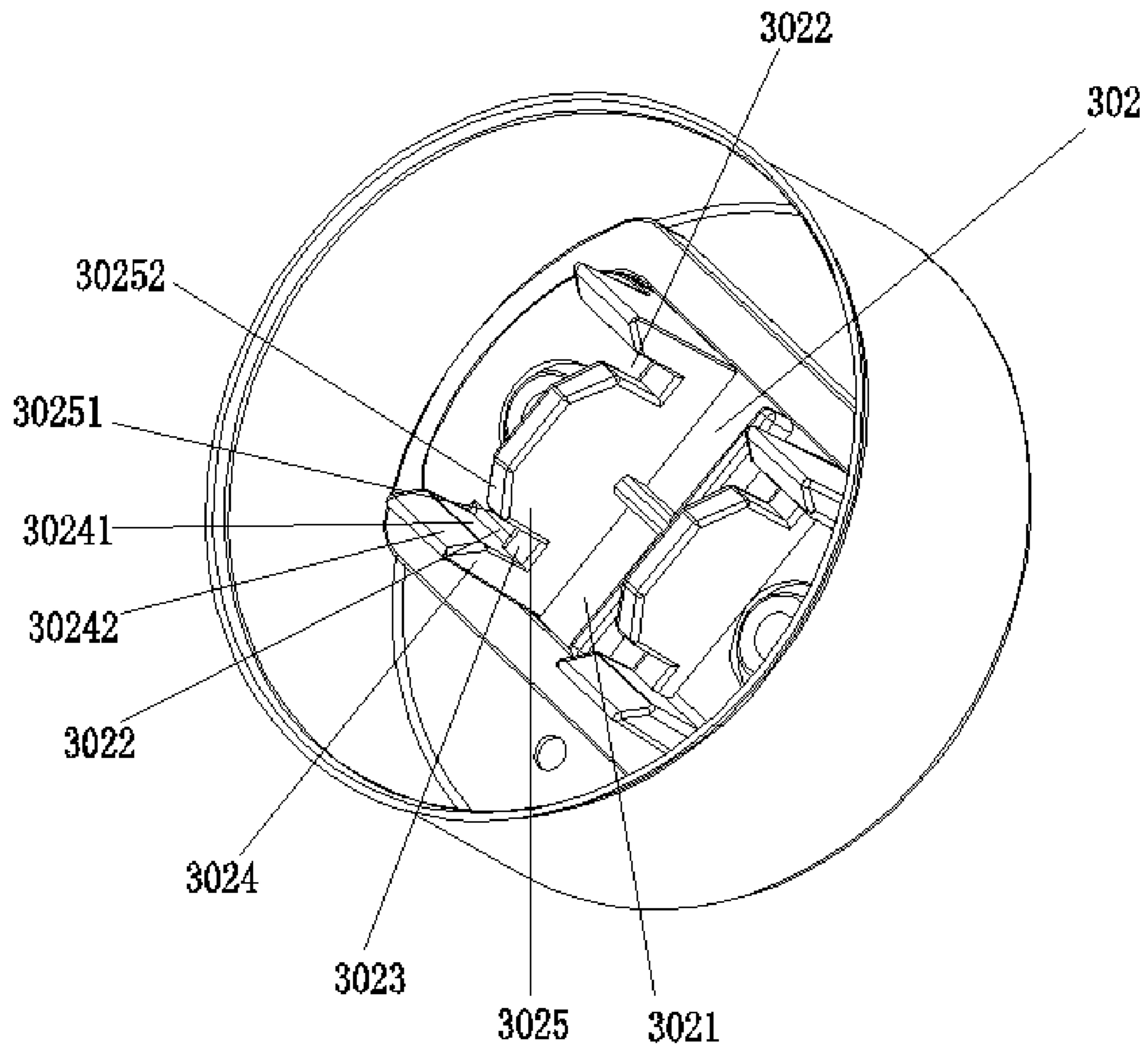


FIG. 16

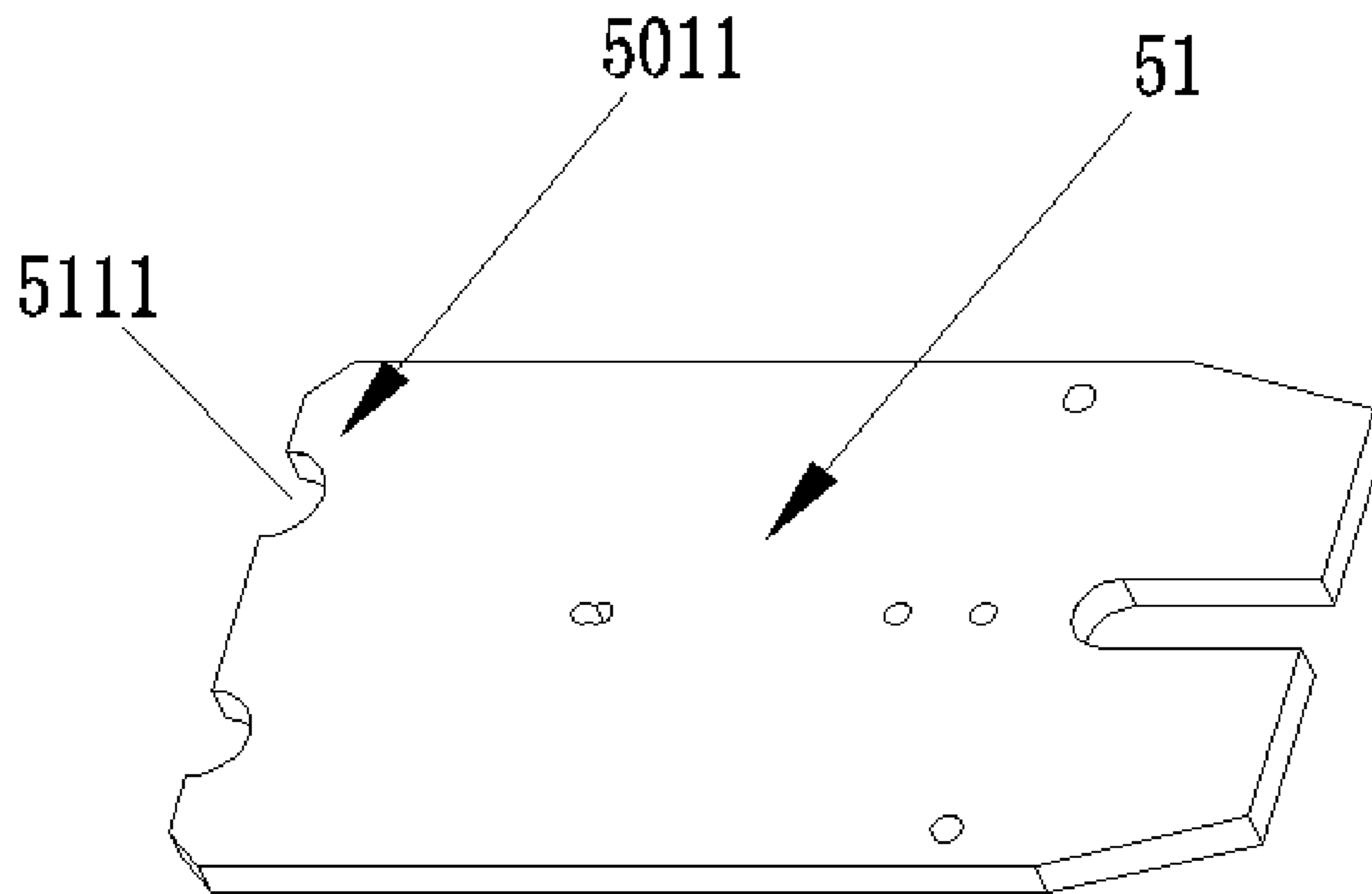


FIG. 17

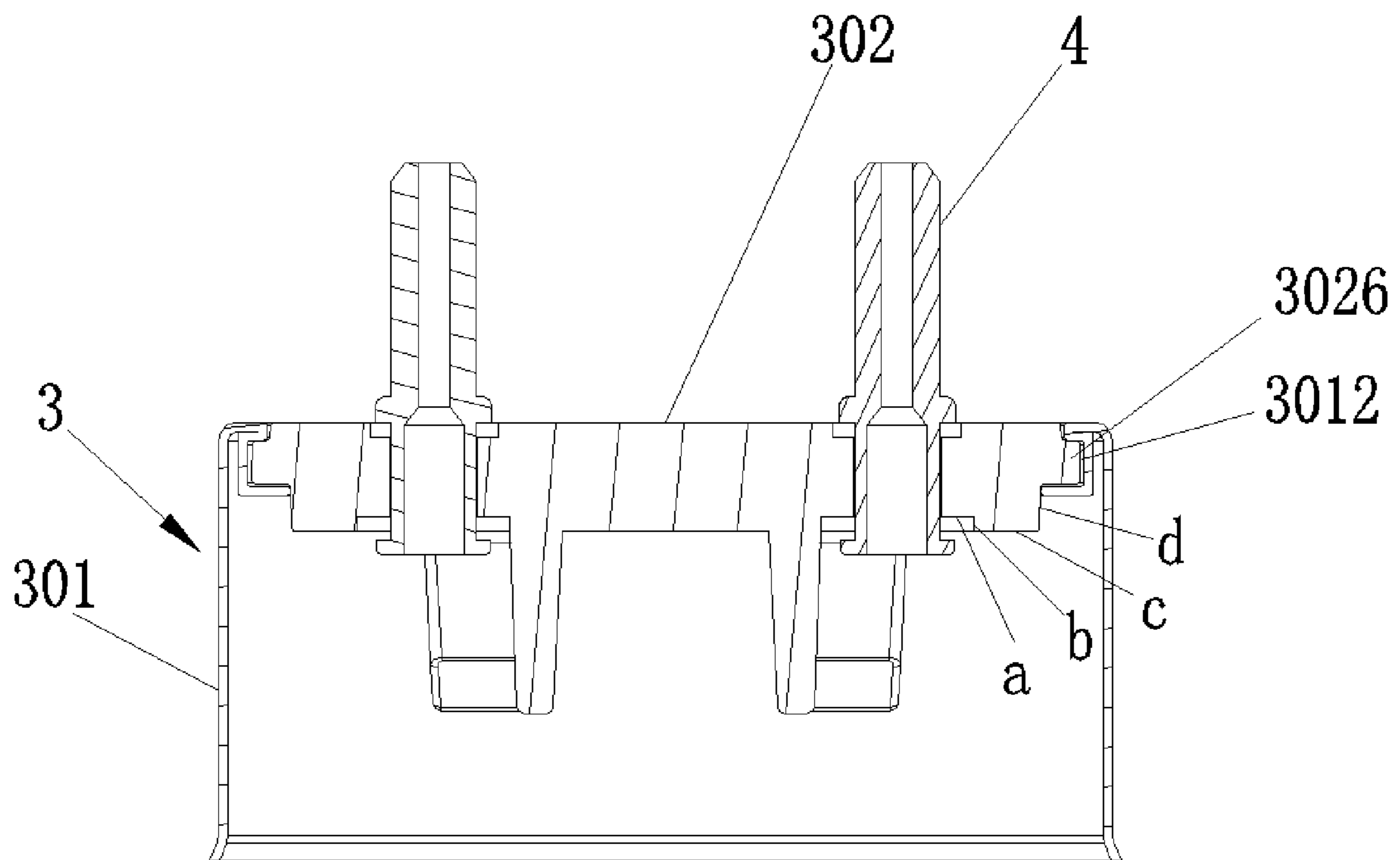


FIG. 18

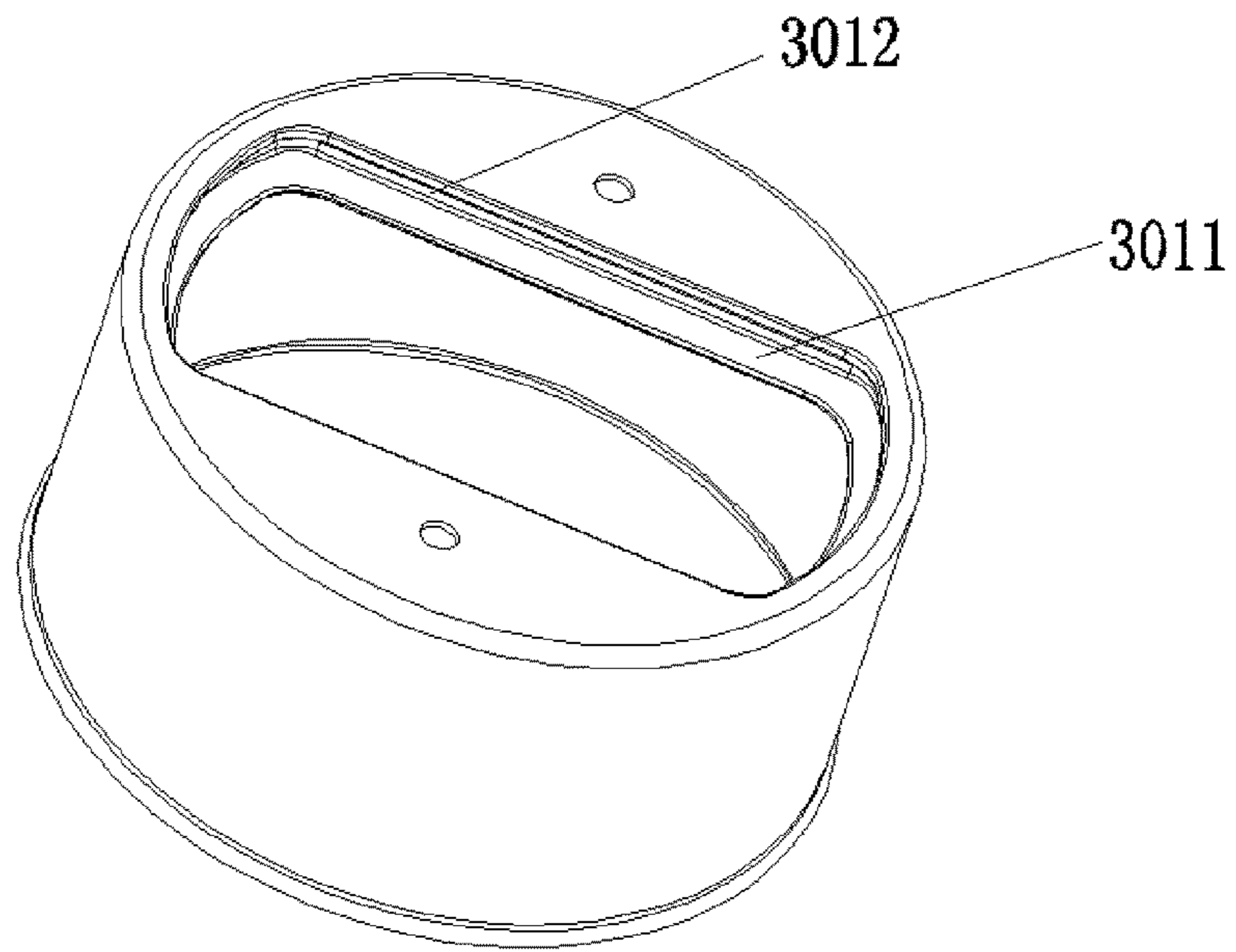


FIG. 19

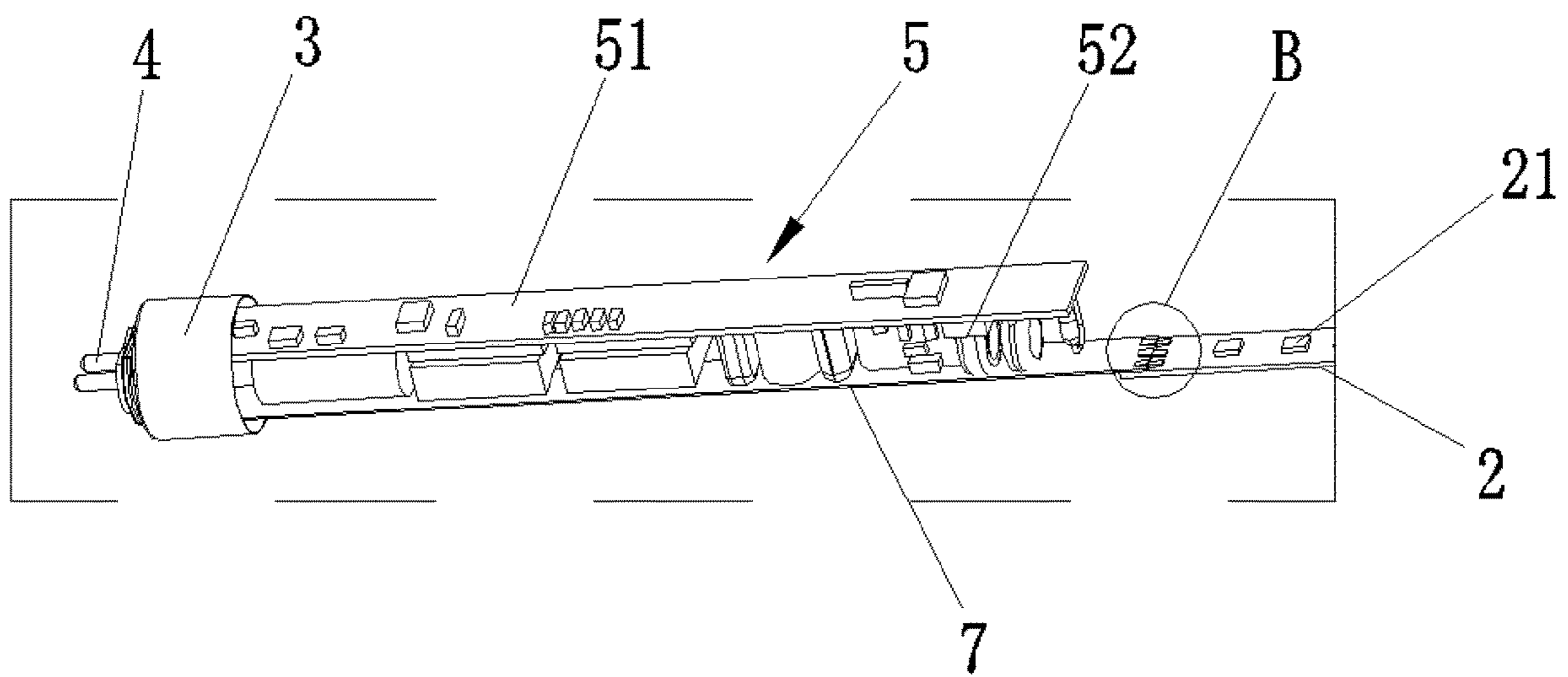


FIG. 20

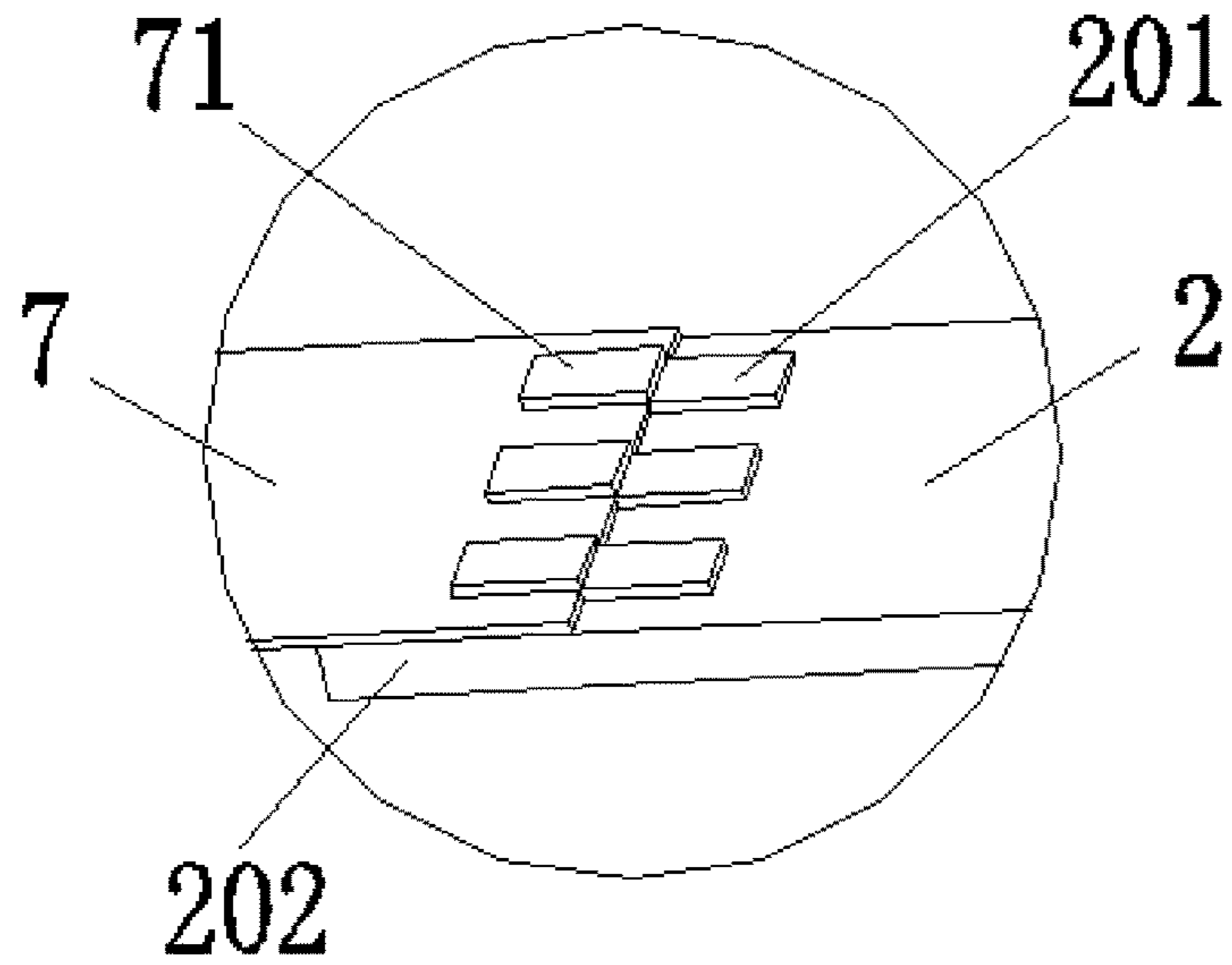


FIG. 21

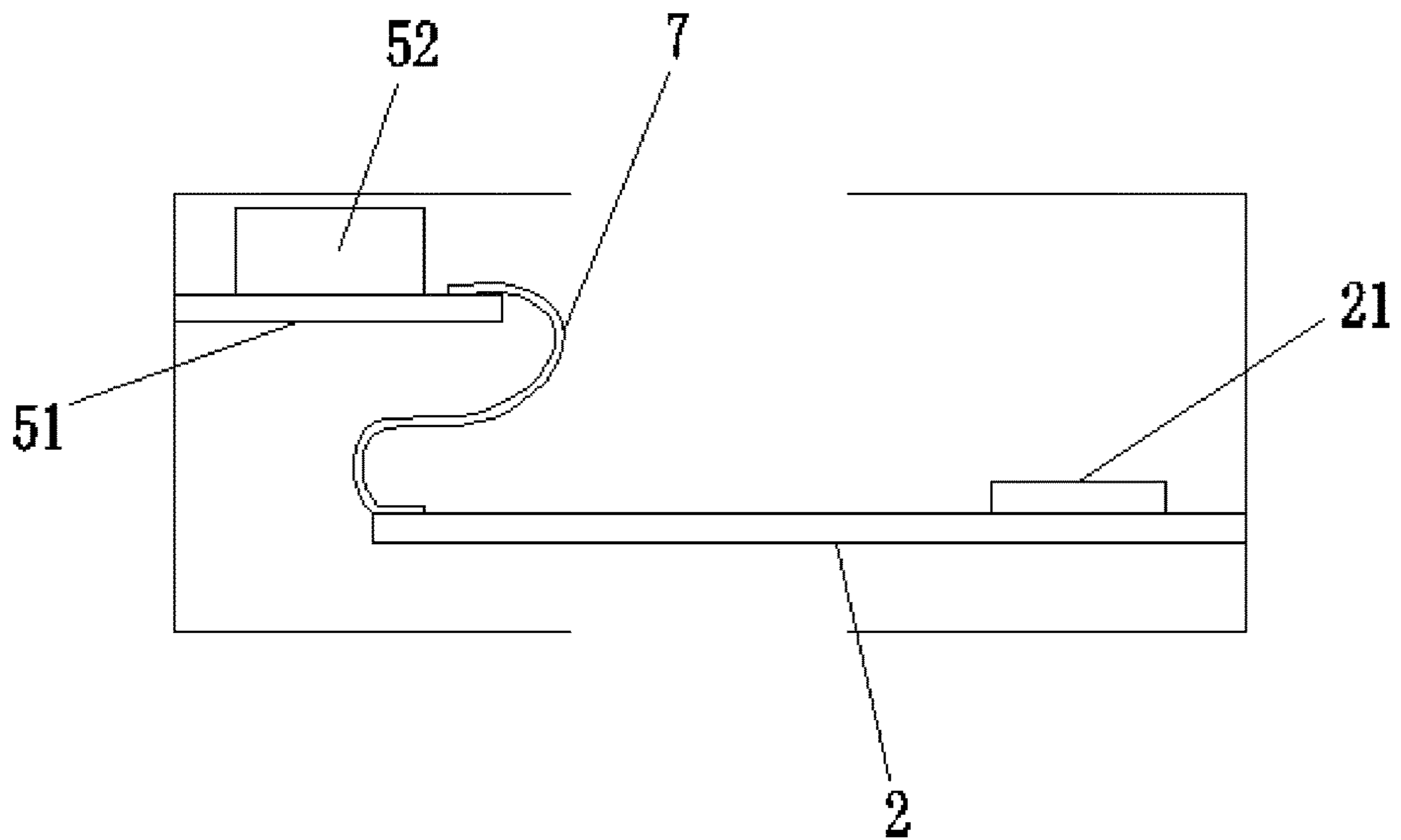


FIG. 22



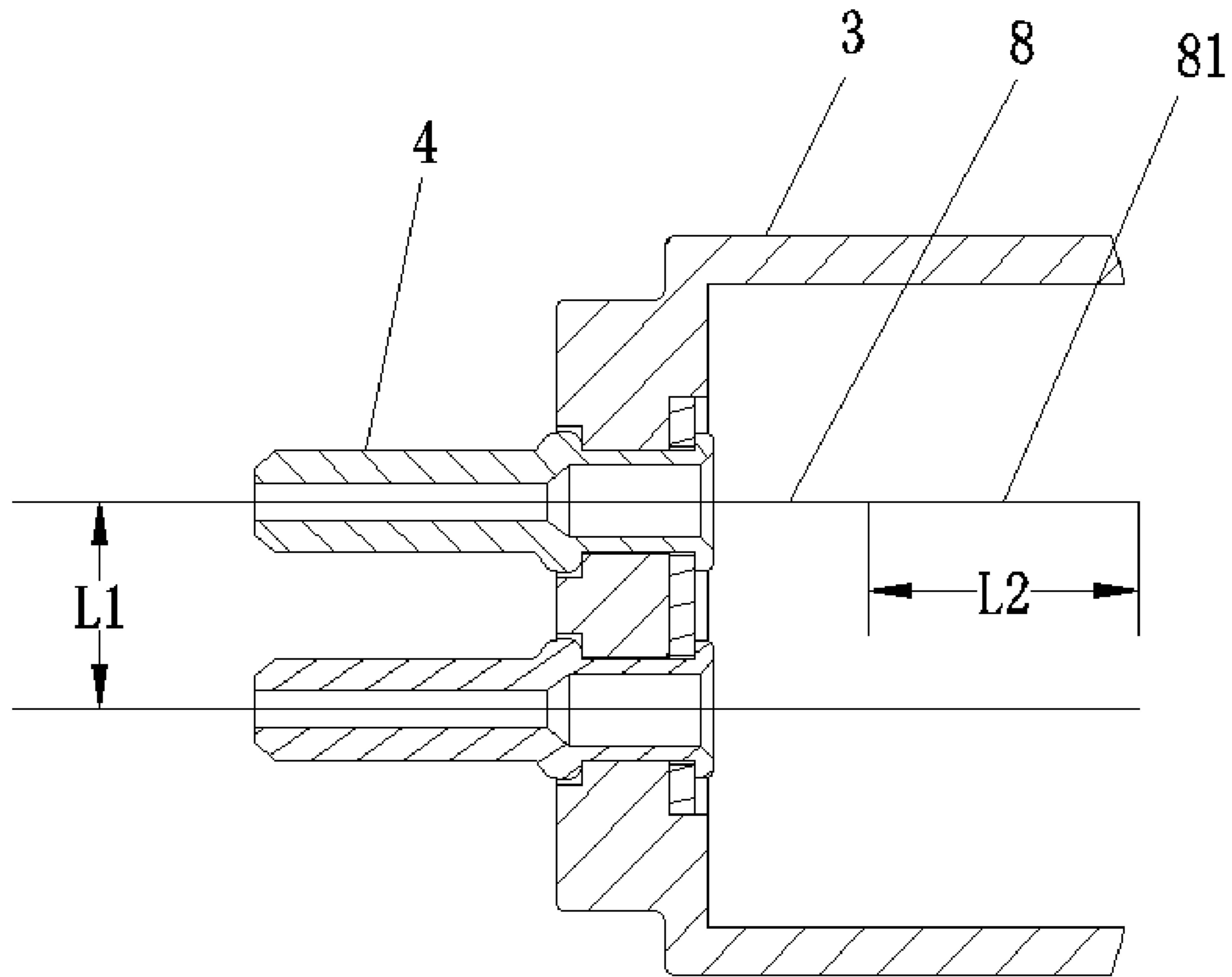


FIG. 23

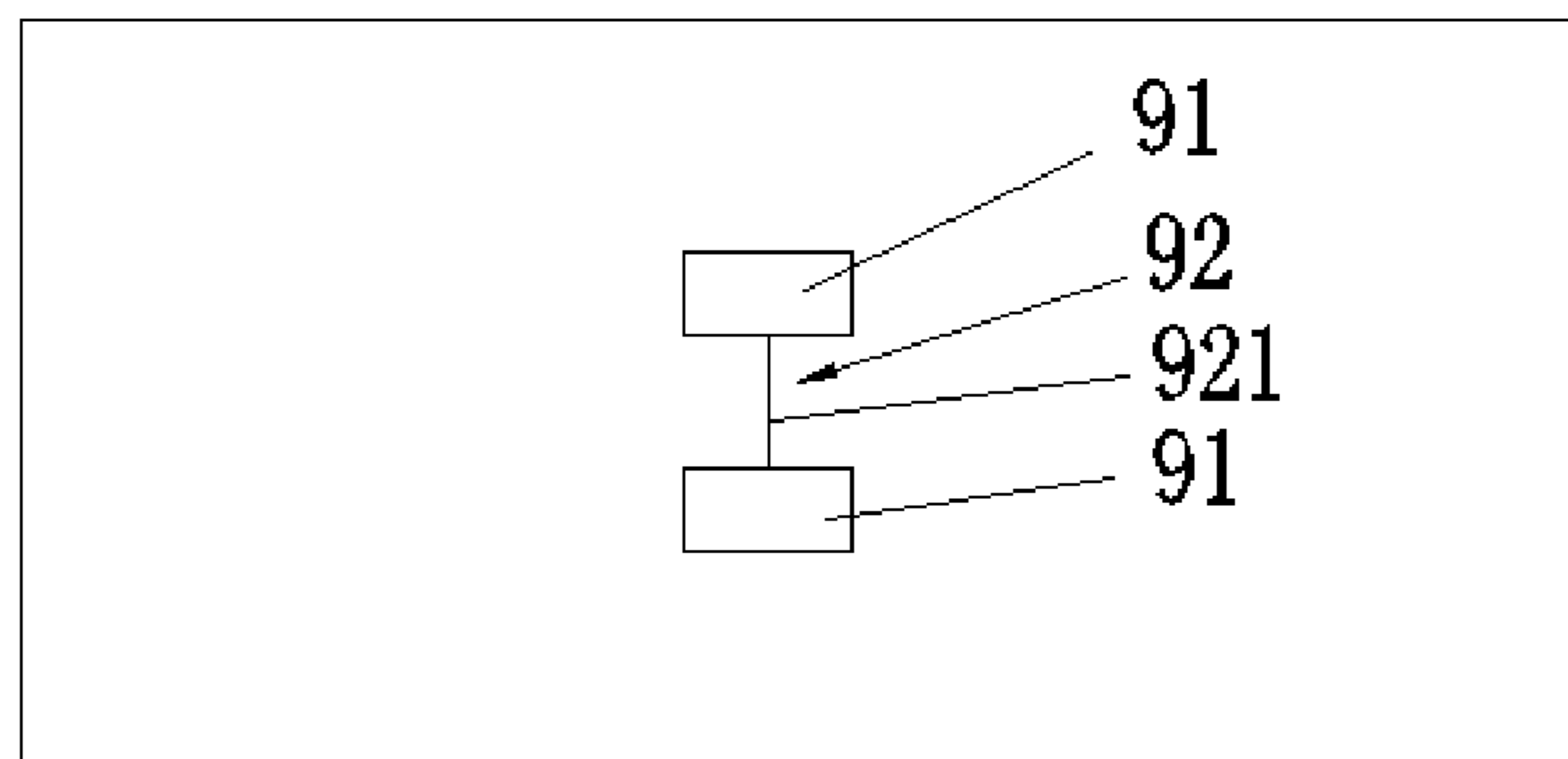


FIG. 24

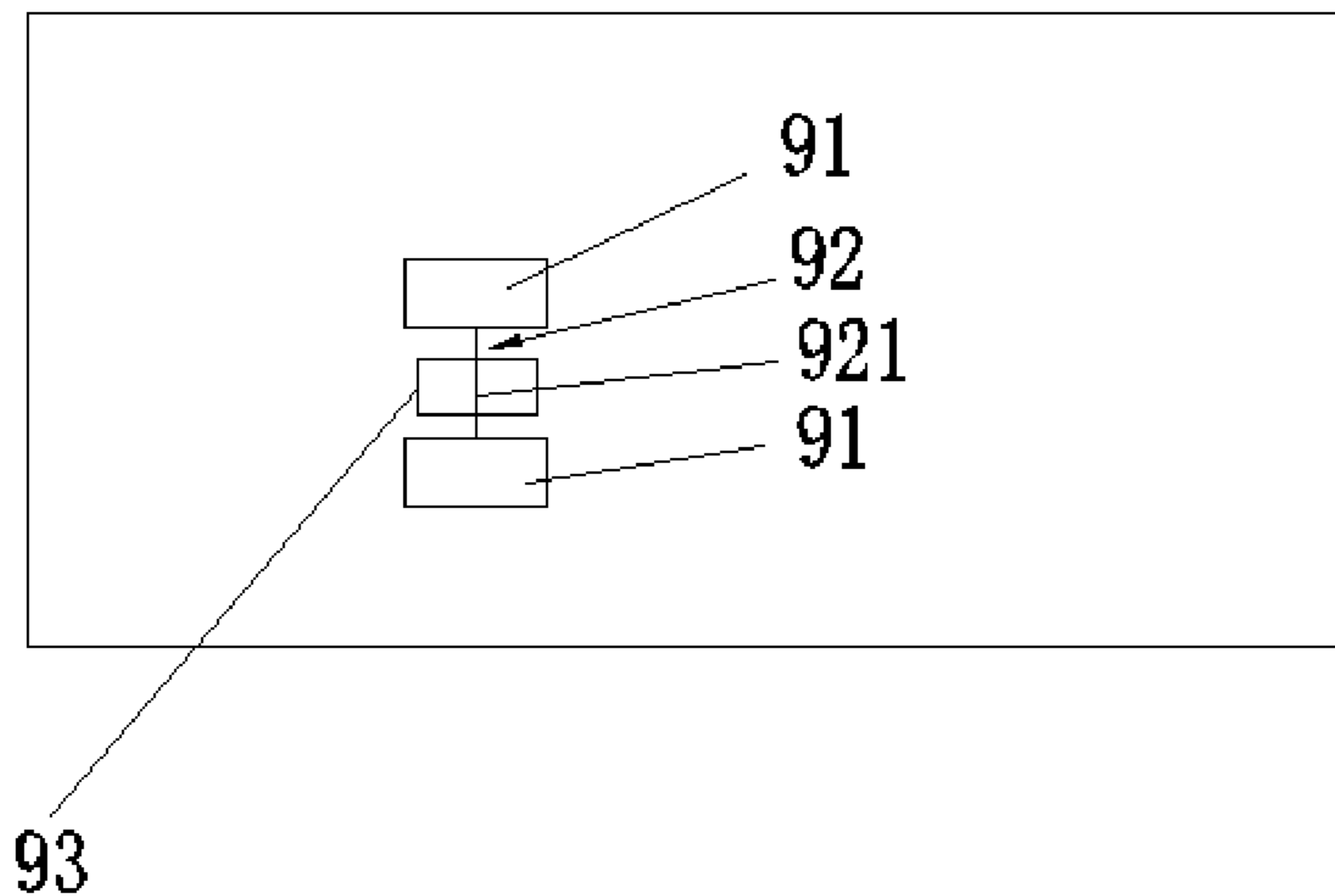


FIG. 25

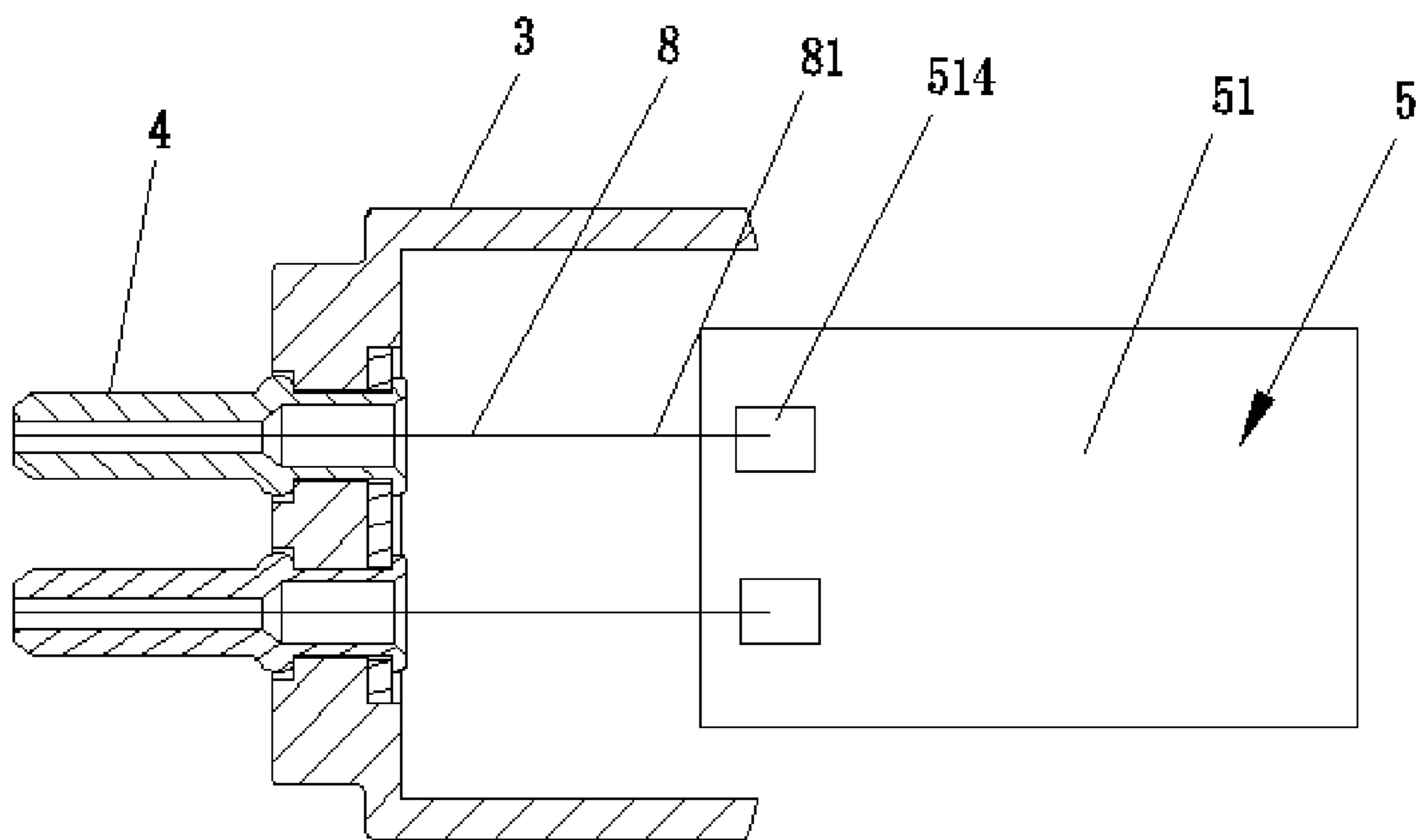


FIG. 26

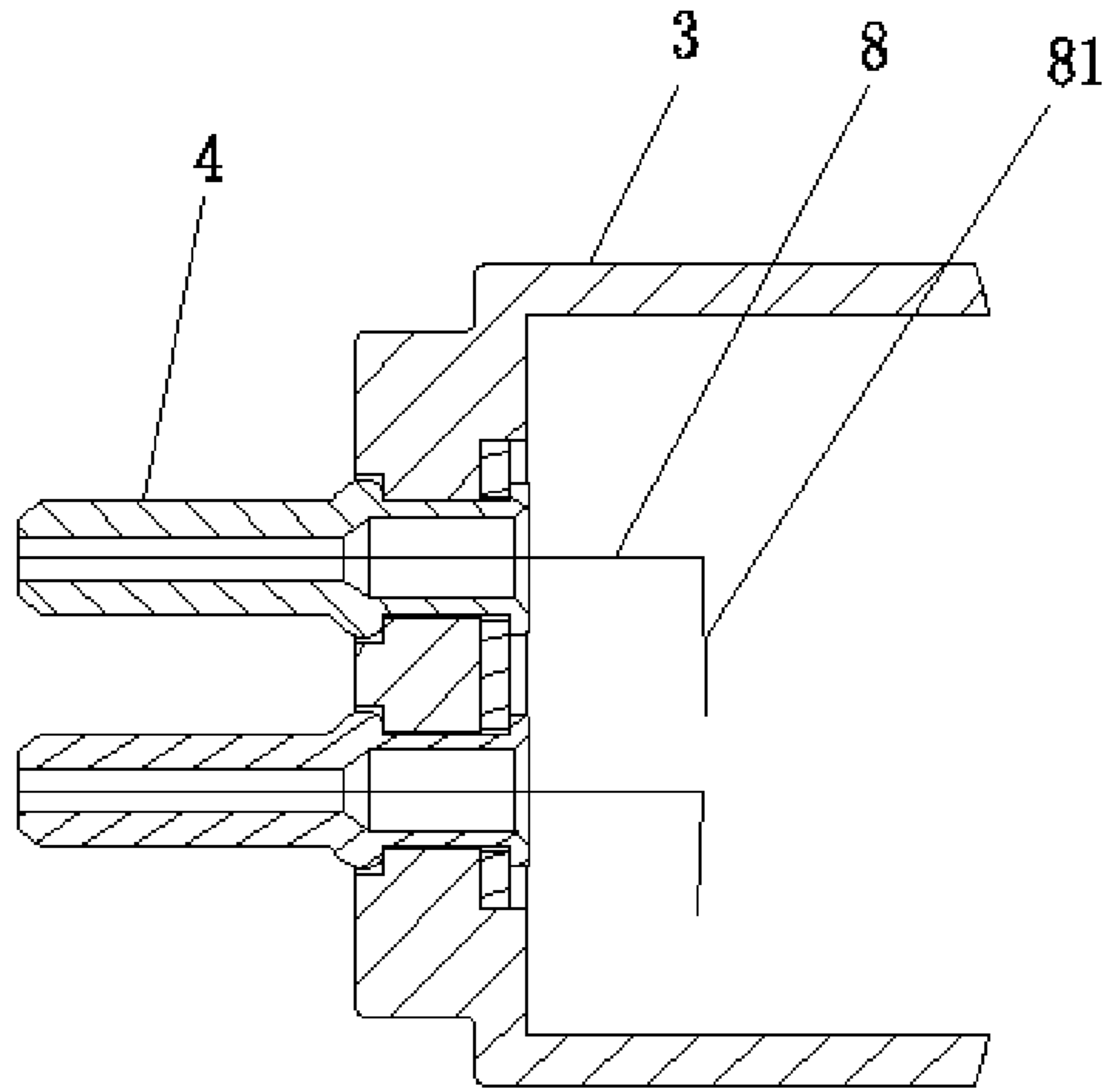


FIG. 27

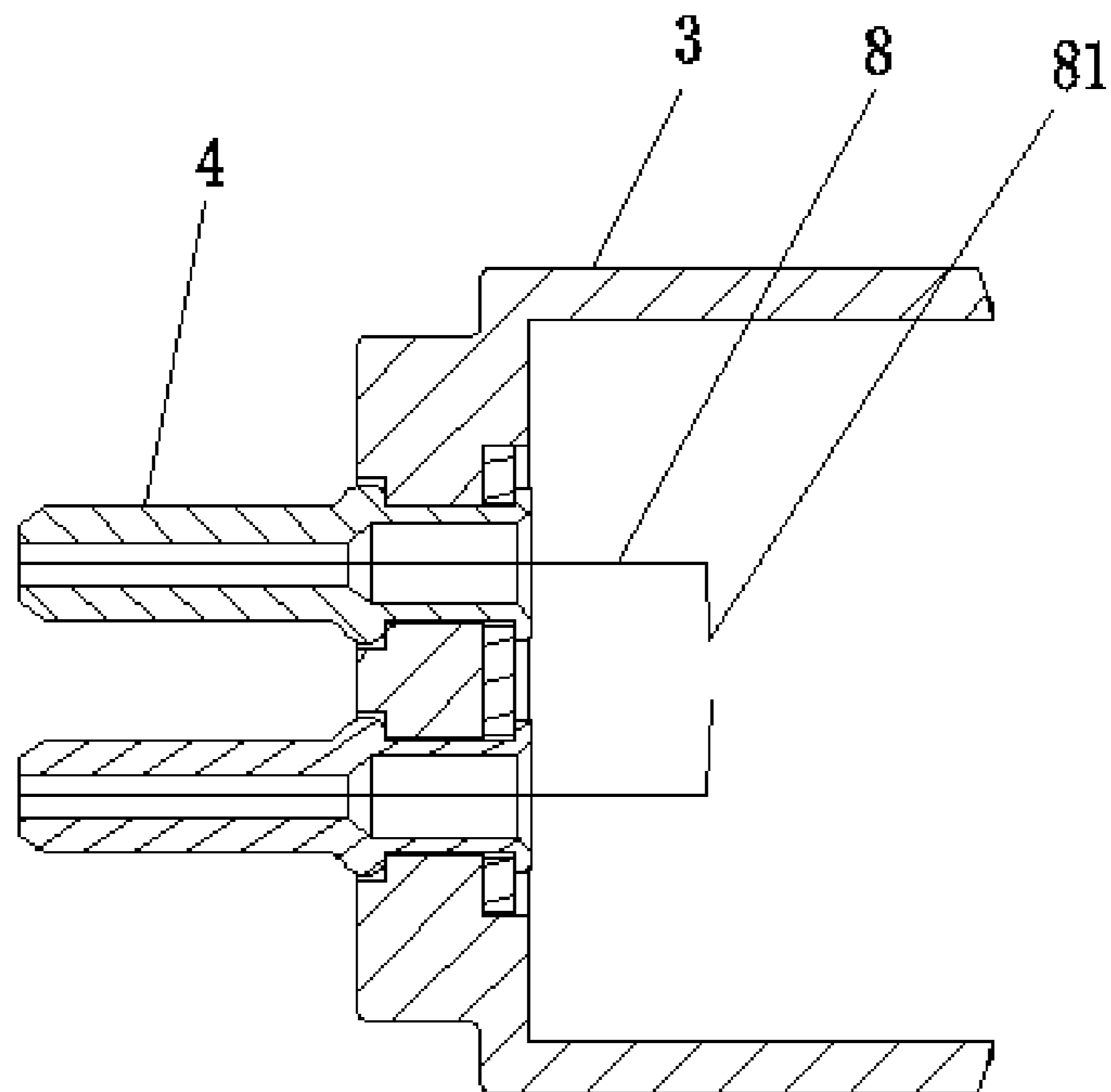


FIG. 28

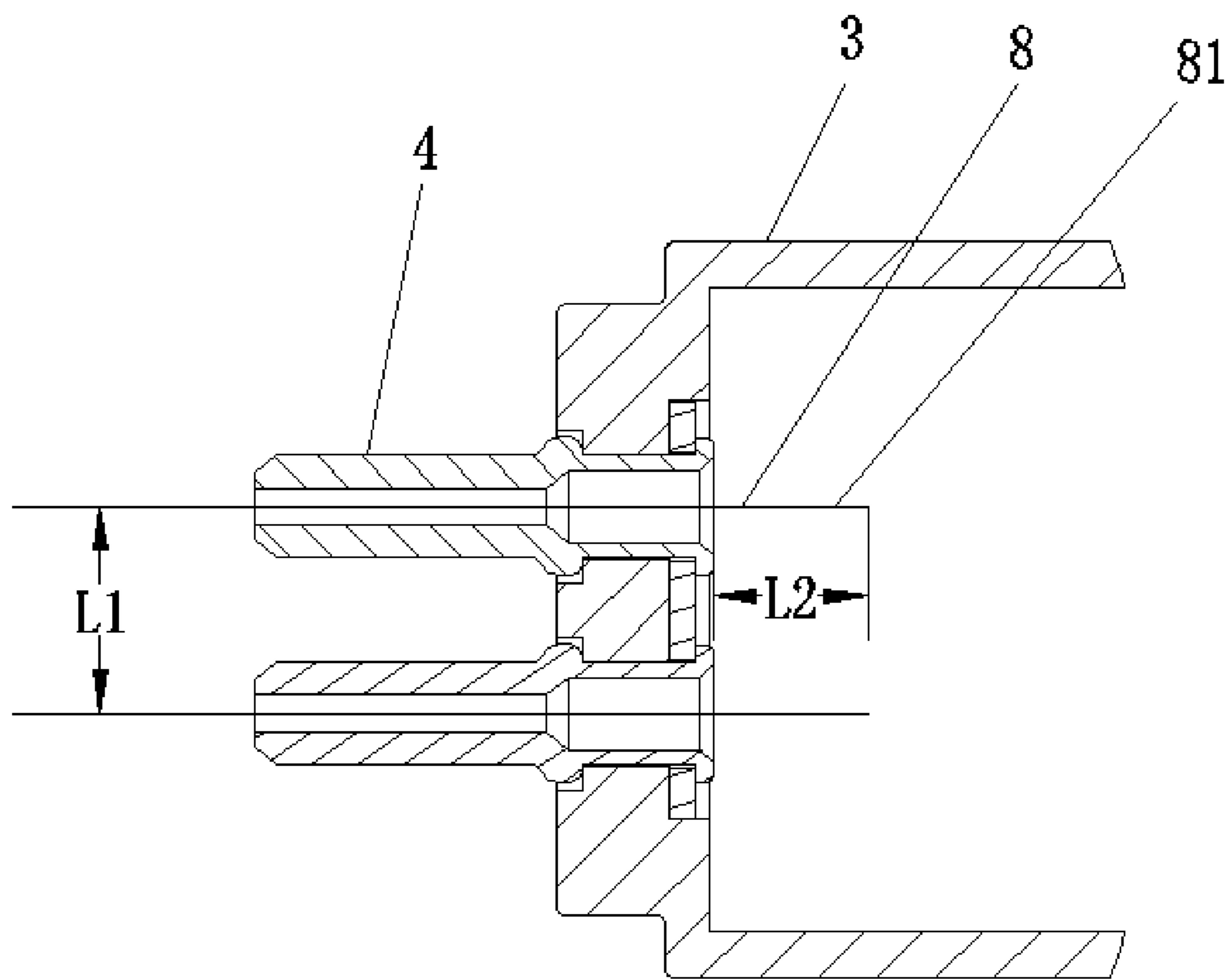


FIG. 29

# 1

## LED TUBE LAMP

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. application Ser. No. 16/731,342 filed on 2019 Dec. 31, which claims priority to the following Chinese Patent Applications Nos.: CN 201910001656.8 filed on 2019 Jan. 2, CN 201910152736.3 filed on 2019 Feb. 28, CN 201910506394.0 filed on 2019 Jun. 12, CN 201910516229.3 filed on 2019 Jun. 14, CN 201911179027.0 filed on 2019 Nov. 27, the disclosures of which are incorporated herein in their entirety by reference.

### TECHNICAL FIELD

The present disclosure relates to an LED lighting device, and more particularly, to an LED tube lamp.

### RELATED ART

LED lighting is widely used because its benefits of far less energy consumption and longevity. The LED fluorescent lamp, commonly known as a straight tube lamp, generally includes a lamp tube, a first circuit board with a light source disposed in the lamp tube, lamp caps are respectively disposed at both ends of the lamp tube, and a power supply is disposed in the lamp caps. The light source and the power supply are electrical connected through the first circuit board. The light source is made from a plurality of LEDs arranged on the first circuit board, and the plurality of LEDs are sequentially arranged along the length of the lamp tube.

The traditional LED tube lamp includes a second circuit board (electronic components are installed on the second circuit board to form a power supply), a first circuit board and a lamp cap. The second circuit board far from the end of its matched lamp cap connects with the first circuit board.

Assuming that the first circuit board is a flexible circuit board, and the connection between the second circuit board (power circuit board) and the first circuit board (flexible circuit board) needs to be completed outside the lamp tube (the diameter of the lamp is relatively small that it is difficult to achieve the connection between the power circuit board and the flexible circuit board in the lamp tube), when the connection is completed, the power circuit board is inserted into the lamp tube. There are disadvantages of this method:

1. After the connection between the power circuit board and the flexible circuit board is completed outside the lamp tube, the power circuit board needs to be inserted into the lamp tube, and the process of inserting the power circuit board into the lamp is rather difficult, especially product T5 because the diameter of product T5 is smaller, it is more difficult to insert into the power circuit board.

2. The end of the flexible circuit board needs to be provided with a free portion. Therefore, during the insertion of the power circuit board into the lamp tube, the free portion can be driven into the lamp tube. The length of the free portion needs to be at least longer than that of the power circuit board from outside the lamp tube. If the length of the free portion is too long, the stability of the connection will be lowered. After the power circuit board is inserted into the lamp tube, the arrangement of the free portion in the lamp tube cannot be controlled, and the light source may be blocked, such uncertainties may appear.

3. After the connection between the power circuit board and the flexible circuit board is completed, during the

# 2

process of inserting the power circuit board into the lamp tube, the flexible circuit board may be stripped from the power circuit board due to dragging, resulting in connection failure.

4. When the power circuit board is in direct contact with the flexible circuit board, and there is a risk of fire.

5. The thermal conductivity of the flexible circuit board is relatively poor. The heat generated during the operation of the light source may not be dissipated in time. Under long-term high-temperature environment, it is easy to damage the light source or the electronic components of the power supply.

6. The supportability of the flexible circuit board is relatively poor. After the light source is set on the flexible circuit board, the problem that each LED lamp bead is not on the same plane is prone to cause some light emission problems.

In summary, in view of the shortcomings and defects of the existing LED tube lamp, how to design an LED tube lamp is a technical problem that needs to be solved by those skilled in the art.

### SUMMARY

The present disclosure is directed to a new LED tube lamp and features in various aspects to solve the above problems.

The present disclosure provides an LED tube lamp comprising a lamp tube; a first circuit board, disposed in the lamp tube, having a plurality of light sources mounted thereon; two lamp caps disposed at respective ends of the lamp tube; a power supply substantially disposed in one or both of the two lamp caps, the power supply having a second circuit board; and a connection structure having a third circuit board, the third circuit board for connecting the first circuit board to the second circuit board thereby connecting the light sources to the power supply.

In some embodiments, the thermal conductivity of the first circuit board is higher than that of the third circuit board.

In some embodiments, the thermal conductivity of the third circuit board is higher than that of the second circuit board.

In some embodiments, the power supply includes an electronic component, the electronic component of the power supply includes one or more heating elements, at least one of the heating elements of the electronic component thermally contacts to the third circuit board.

In some embodiments, the power supply includes an electronic component, the electronic component of the power supply includes a heating element, the heating element for dissipating heat in the form of heat radiation to the third circuit board.

In some embodiments, the hardness of the first circuit board is greater than that of the third circuit board.

In some embodiments, the hardness of the second circuit board is greater than that of the third circuit board, the power supply and the third circuit board are stacked, and the third circuit board is bent and deformed to adapt to the power supply.

In some embodiments, the first circuit board is fastened on the inner surface of the lamp tube while the third circuit board is not fastened on the inner surface of the lamp tube, the third circuit board is a soft circuit board or a flexible circuit board.

In other embodiments, the second circuit board has a first end and a second end in a axial direction of the lamp tube, and the first end of the second circuit board is closer to the



matching lamp cap, the first end of the second circuit board is connected to one end of the third circuit board while the other end of the third circuit board is connected to the first circuit board.

In some embodiments, the second circuit board is directly soldered to the third circuit board.

In some embodiments, the first circuit board has a first pad, and the third circuit board has a second pad, the first circuit board and the third circuit board are directly soldered through the first pad and the second pad.

In some embodiments, the first pad of the first circuit board is spaced from the end of the first circuit board in a longitudinal direction to form a connection section, one end of the third circuit board is placed on the connection section and the second pad of the third circuit board corresponds to the first pad of the first circuit board in the length direction of the lamp tube.

In some embodiments, the connection section is a part of the first circuit board, and the hardness of the connection section is higher than that of the third circuit board.

In some embodiments, the power supply includes an electronic component, the first pad of the first circuit board is disposed on a side of the first circuit board with the light sources, and the second pad of the third circuit board is disposed on a side of the third circuit board relatively close to a side of the electronic component.

In some embodiments, the second circuit board and the third circuit board are separated by the electronic component.

In some embodiments, the electronic components include capacitor, transformer or inductor.

In some embodiments, the second circuit board and the third circuit board are disposed at opposite sides in the width direction of the lamp tube.

In some embodiments, the thickness of the third circuit board is smaller than that of the second circuit board.

In some embodiments, a hollow conductive pin is arranged on the lamp cap, the LED tube lamp includes a connecting wire, and the hollow conductive pin is fastened on the lamp cap, one end of the connecting wire is electrically connected to the hollow conductive pin, the other end of the connecting wire is connected to the second circuit board, the connecting wire includes a fusible portion and the fusible portion is a low-melting alloy.

In some embodiments, the melting point of the fusible portion is less than or equal to the melting point of any conductive substance on the second circuit board.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a three-dimensional exploded diagram of an LED tube lamp according to an embodiment of the instant disclosure;

FIG. 2 illustrates a perspective diagram of a lamp cap according to an embodiment of the instant disclosure;

FIG. 3 illustrates a schematic diagram showing the lamp cap connected to the second circuit board in FIG. 2;

FIG. 4 illustrates a three-dimensional schematic diagram showing the lamp cap structure in FIG. 2;

FIG. 5 illustrates a perspective diagram of a lamp cap according to an embodiment of the instant disclosure;

FIG. 6 illustrates a schematic diagram showing the lamp cap connected to the second circuit board in FIG. 5;

FIG. 7 illustrates a three-dimensional schematic diagram showing the lamp cap structure in FIG. 3;

FIG. 8 illustrates a perspective diagram of showing the lamp cap connected to the second circuit board;

FIG. 9 illustrates a three-dimensional schematic diagram showing the lamp cap structure in FIG. 8;

FIG. 10 illustrates a perspective diagram of showing the lamp cap according to an embodiment of the instant disclosure;

FIG. 11 illustrates a schematic diagram showing the lamp cap connected to the second circuit board in FIG. 10;

FIG. 12 illustrates a three-dimensional schematic diagram showing the lamp cap structure in FIG. 10;

FIG. 13 illustrates a perspective diagram of showing the lamp cap structure according to other embodiments of the instant disclosure;

FIG. 14 illustrates a perspective diagram of showing the lamp cap structure according to an embodiment of the instant disclosure;

FIG. 15 illustrates a partially steric cross section of the lamp cap structure according to an embodiment of the instant disclosure;

FIG. 16 illustrates a three-dimensional schematic diagram showing the lamp cap structure;

FIG. 17 illustrates a three-dimensional schematic diagram showing the second circuit board structure;

FIG. 18 illustrates a cross section diagram of the lamp cap structure;

FIG. 19 illustrates a three-dimensional schematic diagram showing the second circuit board structure;

FIG. 20 illustrates a partial diagram showing the connection structure of the power supply and the first circuit board according to an embodiment of the instant disclosure;

FIG. 21 illustrates a zoom-in diagram showing the structure B in FIG. 20;

FIG. 22 illustrates a partial schematic diagram showing the connection structure of the second circuit board and the first circuit board according to other embodiments of the instant disclosure;

FIG. 23 illustrates a cross section diagram of partial perspective diagram of the LED tube lamp according to an embodiment of the instant disclosure;

FIG. 24 illustrates a perspective diagram showing circuit board 1 according to an embodiment of the instant disclosure;

FIG. 25 illustrates a perspective diagram showing circuit board 2 according to an embodiment of the instant disclosure;

FIG. 26 illustrates a cross section diagram showing the connection of the wire and the second circuit board;

FIG. 27 illustrates a cross section diagram showing state I of the fusing part folded;

FIG. 28 illustrates a cross section diagram showing state II of the fusing part folded; and

FIG. 29 illustrates a cross section diagram of partial perspective diagram of the LED tube lamp according to an embodiment of the instant disclosure.

#### DETAILED DESCRIPTION

In order to better understanding of the present disclosure, the present disclosure will be described more fully with reference to the accompanying drawings. The drawings show a preferred embodiment of the disclosure. However, the present disclosure is implemented in many different forms and is not limited to the embodiments described below. Rather, these embodiments provide a thorough understanding of the present disclosure. The following directions such as "axial direction", "upper", "lower" and the like are for more clearly indicating the structural position relationship, and are not a limitation on the present inven-



## 5

tion. In the present invention, the “vertical”, “horizontal”, and “parallel” are defined as: including the case of  $\pm 10\%$  based on the standard definition. For example, vertical usually refers to an angle of 90 degrees with respect to the reference line, but in the present invention, vertical refers to a condition including 80 degrees to 100 degrees.

Please refer to FIG. 1, the instant disclosure provides an embodiment of the LED tube lamp which comprises a lamp tube 1, a first circuit board 2 disposed in the lamp tube 1 and two lamp caps 3 respectively disposed at both ends of the lamp tube 1, and a hollow conductive pins 4 for connecting an external power supply is disposed on the two lamp caps 3. The lamp tube 1 is a plastic lamp tube, a glass lamp tube, or a plastic and metal mixed lamp tube, or a glass and metal mixed lamp tube. The size of the two lamp caps 3 (the axial length dimension of the lamp cap 3) is the same or different. The instant disclosure provides an embodiment of multiple light sources 21 set on the first circuit board 2. When the light source 21 is in operation, the light source 21 forms a heat conduction path with the lamp tube 1 and the first circuit board 2. In this way, it is convenient to quickly dissipate the heat generated from the inside of the lamp tube 1 to the outside of the lamp tube 1 during the operation of the light source 21. The instant disclosure provides an embodiment of the first circuit board 2 being fixed to the inner surface of the lamp tube 1 by an adhesive, that is, the first circuit board 2 is fixed to the inner surface of the lamp tube 1 by an adhesive. The first circuit board 2 forms a heat conduction path with the lamp tube 1 through glue. In some embodiments, the first circuit board 2 is fixed to the inner surface of the lamp tube 1 with a thermally conductive adhesive to improve the thermal conductivity. A power supply 5 is disposed in the lamp caps 3, and the power supply 5 and the light source 21 are electrically connected by the first circuit board 2. At least a part of the power supply 5 in a radial projection of the LED tube lamp overlaps the lamp caps 3. The power supply 5 can be a single unit (for example, the power supply modules are all concentrated in one component and disposed in one of the lamp caps 3 (non-light-emitting area)). Alternatively, the power supply 5 is also divided into two parts, which are called dual bodies (that is, all power supply modules are respectively installed in two parts), and the two parts are respectively installed in the lamp caps 3 (non-light-emitting areas) at both ends of the lamp tube 1. In this embodiment, the power supply 5 includes a second circuit board 51 (as shown in FIG. 3) and a plurality of electronic components 52.

Please refer to FIG. 2 to FIG. 4, the instant disclosure provides an embodiment of a lamp cap 3 which can be applied to an LED tube lamp. The lamp cap 3 includes a side wall 31 and an end wall 32. The side wall 31 is tubular. The side wall 31 and the lamp tube 1 are coaxially set and connected to each other. The meaning of coaxial is that the lamp cap 3 and the lamp tube 1 may have tolerances during manufacture, so the axes of the lamp cap 3 and the lamp tube 1 may be slightly offset, but generally the lamp cap 3 and the lamp tube 1 are coaxial. The plane of the end wall 32 is vertical or substantially vertical to the axial direction of the side wall 31, and the end wall 32 connects to the end of the side wall 31 away from the lamp tube 1. The meaning of vertical is that the end wall 32 and the side wall 31 may have tolerances during manufacture, so the end wall 32 and the side wall 31 are not 90 degrees vertical but slightly inclined, and this still belongs to the vertical range. However, even if the end wall 32 is slightly inclined with respect to the axial direction of the side wall 31, the end wall 32 and the side wall 31 may form a space for installing the power supply 5

## 6

and may match the lamp holder. The side wall 31 and the end wall 32 form an internal space of the lamp cap 3, and the power supply 5 is at least partially installed in the internal space of the lamp cap 3.

As shown in FIG. 2, the lamp cap 3 includes a first rib 33. The first rib 33 is set on the inner surface of the side wall 31 of the lamp cap 3, and the first rib 33 extends in the axial direction of the lamp cap 3. The first rib 33 may be continuously integrated in the axial direction of the lamp cap 3 or may be multi-segmented. The first rib 33 and the inner surface of the side wall 31 form a slot 35, and the second circuit board 51 is inserted into the slot 35 and fixed. In specific, please refer to FIG. 3, the second circuit board 51 has a first surface 511 and a second surface 512 which are opposite and parallel to each other, and the first surface 511 and the second surface 512 are substantially parallel to the axial direction of the lamp cap 3. When the second circuit board 51 is inserted into the slot 35 and fixed, the first surface 511 of the second circuit board 51 corresponds to the surface on the side of the first rib 33, and the second surface 512 of the second circuit board 51 corresponds to the inner surface of the side wall 31, so the second circuit board 51 is fixed. Preferably, the first surface 511 of the second circuit board 51 abuts on the first rib 33, and the edge of the second surface 512 of the second circuit board 51 abuts on the inner surface of the side wall 31 so that the circuit board 51 is fastened. In actual use, the first rib 33 are used in pairs, that is, the slot 35 is formed on the two sides of the lamp cap 3 to fasten the two sides of the second circuit board 51. As shown in FIG. 2, the slot 35 are arranged in four groups, that is, two pairs of the slots 35, and the two pairs of slots 35 are arranged symmetrically to each other. Therefore, when the lamp cap 3 is connected to the second circuit board 51, the second circuit board 51 can be selectively inserted into the two pairs of the slots 4 according to the actual position.

In this embodiment, the first rib 33 may be made of an elastic material (such as plastic). In this way, the first rib 33 may provide certain deformed space to adapt an error of the thickness or different sizes of the thickness of the second circuit board 51 during manufacture.

Please refer to FIGS. 2 to 4, a hole 3001 is set on the lamp cap 3. With the setting of the hole 3001, on the one hand, the heat generated by the power module inside the lamp cap 3 is dissipated without causing the inside of the lamp cap 3 to be in a high temperature state. On the other hand, if the humidity is too high, water vapor is formed on the inner wall of the lamp tube 1, which reduces the reliability of the internal components of the lamp cap 3. In another embodiment of the instant disclosure, the holes 3001 are symmetrically arranged with respect to the hollow conductive pinholes of the lamp cap 3, so that no matter the second circuit board 51 is installed in any group of the slots 4, there are corresponding holes 3001 dissipating heat.

As shown in FIG. 5, FIG. 6 and FIG. 7, a lamp cap 3 proposed of the instant disclosure can be applied to an LED tube lamp. The difference between the lamp cap 3 proposed in this embodiment and the lamp cap 3 (the lamp cap 3 shown in FIGS. 2 to 4) of the previous embodiment is that the first rib 33 of the lamp cap 3 is provided with a coupling structure 331, and the coupling structure 331 is protruded set on the first rib 33 with respect to one side surface of the first surface 511 of the second circuit board 51. The coupling structure 331 extends along the axial direction of the lamp cap 3, and the coupling structure 331 may be continuously integrated in the axial direction of the lamp cap 3, or may be a multi-segment type. The coupling structure 331 has a coupling surface 3311, and the coupling surface 3311 cor-



7

responds to the first surface **511** of the second circuit board **51**. For example, the first surface **511** of the second circuit board **51** and the coupling surface **3311** abut. When the second circuit board **51** is fastened, the first surface **511** of the second circuit board **51** corresponds to the coupling surface **3311**, and the second surface **512** thereof corresponds to the inner surface of the side wall **31**, that is, the coupling surface **3311** and the inner surface of the side wall **31** forms a slot **35**. Preferably, the first surface **511** of the second circuit board **51** abuts the coupling surface **3311**, and the edge of the second surface **512** of the second circuit board **51** abuts the inner surface of the side wall **31**, so that the second circuit board **51** is fixed. Compared with the first surface **511** of the second circuit board **51** directly corresponding to the surface on the side of the first rib **33** (the first surface **511** directly contacts the surface on the side of the first rib **33**), the coupling portion **331** can narrow the contact area of the first surface **511** of the second circuit board **51** and when the first rib **33** is small, the contact area is narrowed during the process of inserting the second circuit board **51** into the lamp cap **3**, which can reduce the resistance during insertion.

As shown in FIG. 7, the coupling structure **331** is provided with a first guide unit **3312** at an end of the lamp cap **3** axially away from the end wall **32**. When the first guide unit **3312** is away from the end wall **32**, it is opposite to the first rib **33** where the height of the surface gradually decreases. This facilitates the insertion of the second circuit board **51**.

As shown in FIG. 5, the coupling structure **331** is vertical or substantially vertical to the first rib **33**. When the coupling structure **331** is far from the surface of the first rib **33**, the width dimension of the cross-section thereof gradually shortened. That is, the position which the coupling structure **331** is connected to the first rib **33** has the largest width. In this way, the strength of the connection between the coupling structure **331** and the first rib **33** can be increased, and breakage of the coupling structure **331** at the connection portion with the first rib **33** can be prevented during use. In some embodiments, in order to prevent the connection between the coupling structure **331** and the first rib **33** from being broken, a stress relief method may be adopted. For example, the connection portion between the coupling structure **331** and the first rib **33** is set as a circular arc transition connection (not shown in the drawing).

As shown in FIG. 13, in some embodiments, in order to narrow the contact area between the first rib **33** and the second circuit board **51**, the following settings can be made. The second circuit board **51** is parallel to the axial direction of the lamp cap **3**, and an angle is formed between the first rib **33** and the second circuit board **51**, so that the end of the first rib **33** contacts the first surface **511** of the second circuit board **51** to narrow the contact area between the first rib **33** and the second circuit board **51** and reduce the resistance of the insertion of the second circuit board **51** into the slot **35**. In this embodiment, an angle  $c$  between the first rib **33** and the second circuit board **51** is an acute angle. The contact between the first rib **33** and the second circuit board **51** is a line contact.

As shown in FIG. 8 and FIG. 9, in this embodiment, a lamp cap **3** can be applied to an LED tube lamp. The difference between the lamp cap **3** of this embodiment and the lamp cap **3** (the lamp cap **3** shown in FIGS. 5 to 7) of the foregoing embodiment is that the lamp cap **3** further includes a positioning unit **36** provided on the inner surface of the side wall **31**. It is extended along the axial direction of the lamp cap **3**. The positioning unit **36** corresponds to the

8

side surface of the second circuit board **51** to limit the side surface of the second circuit board **51** and prevent the second circuit board **51** from being deflected from the axial direction of the lamp cap **3**, thereby causing the second circuit board **51** skewed and cannot be inserted when the card slot **35** is inserted.

As shown in FIG. 8, the positioning unit **36** maintains a gap with the side of the second circuit board **51** to prevent the positioning unit **36** from generating a certain resistance when the second circuit board **51** is inserted into the slot **35**. The positioning unit **36** is continuously integrated in the axial direction of the lamp cap **3**.

As shown in FIG. 8, the position of the positioning unit **36** does not exceed the position of the coupling surface **3311** in the width of the lamp cap **3**. In order to prevent the set-up of the positioning unit **36** from affecting the depth of the slot **35** in the width of the lamp cap **3**.

As shown in FIG. 9, a second guide unit **361** features the positioning unit **36** away from the end wall **32** at an end of the lamp cap **3** in the axial direction. As the second guide unit **361** moves away from the end wall **32**, the height of the opposing second guide unit **361** of the inner surface of the side wall **31** gradually descended. This facilitates the insertion of the second circuit board **51**.

As shown in FIG. 10, FIG. 11, and FIG. 12, in this embodiment, a lamp cap **3** can be applied to an LED tube lamp. The difference between the lamp cap **3** of this embodiment and the lamp cap **3** (the lamp cap **3** shown in FIGS. 8 to 9) of the foregoing embodiments is that the lamp cap **3** further includes a second rib **34**. A slot **35** is formed between the first rib **33** (the coupling structure **331** of the first rib **33**) and the second rib **34**, and the second rib **34** is protruded from the inner surface of the side wall **31**. That is, the first surface **511** of the second circuit board **51** corresponds to the first rib **33** (the coupling structure **331** of the first rib **33**), and the second surface **512** of the second circuit board **51** corresponds to the second rib **34**. The side surface of the second circuit board **51** corresponds to the positioning unit **36**. As shown in FIG. 10, the second rib **34** is vertical to the first rib **33**, and an end portion of the second rib **34** corresponds to the coupling structure **331** of the first rib **33**. By making the second rib **34** vertical to the first rib **33** and using the lower end portion of the second rib **34** to correspond to the coupling structure **331**, in use, only the end portion of the second rib **34** contacts the second circuit board **51**, which can narrow the contact area between the second rib **34** and the second circuit board **51** is to reduce the resistance when the second circuit board **51** is inserted.

As shown in FIGS. 10 and 11, the ratio of the width  $a$  of the slot **35** to the thickness  $b$  of the second circuit board **51** is 1:0.9 to 1:1.25. Since the first rib **33** is made of an elastic material, the slot **35** is compatible with a certain range of the thickness of the second circuit board **51** which has a wider applicable field. Preferably, the ratio of the width  $a$  of the slot **35** to the thickness  $b$  of the second circuit board **51** is 1:1 to 1:1.2, so the second circuit board **51** does not loosen after being inserted into the slot **35**.

As shown in FIG. 11 and FIG. 12, the second rib **34** extends in the axial direction of the lamp cap **3**. A third guide portion **341** is set at the end of the second rib **34** away from the end wall **32** in the axial direction of the lamp cap **3**. When the third guide portion **341** moves away from the end wall **32**, the height of the third guide portion **341** gradually descends. This facilitates the insertion of the second circuit board **51**.

The ratio of the thickness of the first rib **33** to the thickness of the side wall **31** (to the thickness of the side wall **31**



partially in contact with the first rib 33) is between 1:0.8 and 1:2.5. That is, the thickness of the first rib 33 and the thickness of the side wall 31 are relatively uniform. The first rib 33 and the lamp cap 3 by resin are integrally molded. When the first rib 33 is formed on the inner surface of the side wall 31 at certain thickness (in the case where the wall thickness is relatively uniform), the outer surface of the side wall 31 is formed less likely to leave marks. If the thickness of the first rib 33 is too thick (beyond the above ratio), on one hand, it will affect the elasticity of the first rib 33, and further affect the insertion of the second circuit board 51; on the other hand, due to the flow ability and internal stress of the resin when the outer surface of the side wall 31 is formed, a mark (a shrinkage mark) is formed on the outer surface of the side wall 31, and the lamp cap 3 is defective.

As shown in FIG. 7, FIG. 9 and FIG. 12, the first guide portion 3312, the second guide portion 361, and the third guide portion 341 are all set relatively to the direction of the slot 35 so that they can operate in the second circuit board 51.

As shown in FIG. 10, FIG. 11 and FIG. 12, a proximal end 37 is set at the other end of the lamp cap 3 axially opposite to the end wall 32. The distance between the proximal end 37 and the end of the first rib 33 close to the proximal end 37 in the axial direction and the proximal end 37 and the end of the second rib 34 close to the proximal end 37 in the axial direction is different. Preferably, the distance between the proximal end 37 and the end of the first rib 33 close to the proximal end 37 in the axial direction is shorter than the distance between the proximal end 37 and the end of the second rib 33 close to the proximal end 37 in the axial direction. That is, the second circuit board 51 first corresponds to the first rib 33 during the insertion process, and the first rib 33 supports or guides the second circuit board 51, and then corresponds to the second rib 34 (the second circuit board 51 is inserted into the slot 35), thereby facilitating the insertion of the second circuit board 51. If the distance between the proximal end 37 and the end of the first rib 33 close to the proximal end 37 in the axial direction is equal to the distance between the proximal end 37 and the end of the second rib 34 close to the proximal end 37 in the axial direction. It is necessary for the second circuit board 51 at the beginning needs to align with the entrance of the slot 35, which increases the difficulty of the insertion of the second circuit board 51.

As shown in FIG. 14, in this embodiment, a lamp cap 3 can be applied to an LED tube lamp. The difference between the lamp cap 3 of this embodiment and the lamp cap 3 (the lamp cap 3 shown in FIG. 10 to 12) of the previous embodiments is that the second rib 34 is convexly set on the inner surface of the side wall 31, and the second rib 34 is parallel or substantially parallel to the first rib 33. The first rib 33 and the second rib 34 form a slot 35, and the second circuit board 51 is snapped into the slot 35 for fastening. In order to narrow the contact area between the slot 35 and the second circuit board 51, a coupling structure 331 is set on at least one of the first rib 33 and the second rib 34. Preferably, a coupling structure 331 is set on the first rib 33 and the second rib 34 each.

In the above embodiments, when the second circuit board 51 is installed in the end cap 3, the second circuit board 51 and the shaft center of the lamp cap 3 maintain a distance. Therefore, the first surface 511 of the second circuit board 51 corresponds to more space in the lamp cap 3, and the second surface 512 of the second circuit board 51 corresponds to a relatively small space in the lamp cap 3. Therefore, the electronic components of the power supply 5 are being set,

the first surface 511 is set on larger electronic components, such as capacitors, transformers, inductors, etc., and the second surface 512 is set on smaller electronic components, such as chip resistors, chip capacitor, IC (control circuit).

Referring to FIG. 15 and FIG. 16, in this embodiment, a lamp cap 3 can be applied to an LED tube lamp. The lamp cap 3 includes a body 301 and an insulating portion 302. The insulating portion 302 constitutes at least a part of an end portion of the lamp cap 3, and a hollow conductive pin 4 is disposed on the insulating portion 302. The insulating portion 302 has an inner side surface 3021, and a slot 3022 is set on the inner side surface 3021. The longitudinal width of the slot 3022 matches with the second circuit board 51 so that the second circuit board 51 can be inserted into the slot 3022 for fastening. This achieves the function of fastening the power supply 5 in the lamp cap 3. In specific, the slot 3022 restricts the power supply 5 from moving in the up and down direction on the surface of the second circuit board 51. The material of the body 301 in this embodiment is aluminum or an aluminum alloy, and the insulating portion 302 is made of an insulating material, such as plastic, ceramic, or the like. In this embodiment, two sets of the slots 3022 are installed, and the two sets of the slots 3022 are symmetrically installed on the insulating portion 302. The second circuit board 51 can be inserted into one of the two sets of the slots 3022 according to actual assembly conditions. Specifically, the two sets of the slots 3022 are symmetrically installed with respect to a plane passing through the axis of the lamp tube 1 and parallel to the plane of the second circuit board 51.

Please refer to FIG. 15, FIG. 16 and FIG. 17, in this embodiment, the insulating portion 302 includes a bottom wall 3023, a first side wall 3024, and a second side wall 3025, and the bottom wall 3023, the first side wall 3024, and the second side wall 3025 form the slot 3022 and the end of the bottom wall 3023 form the bottom of the slot 3022. The end of the bottom wall 3023 and the inner side surface 3021 maintain space. Therefore, after the second circuit board 51 of the power supply 5 is inserted into the slot 3022, the second circuit board 51 can maintain space from the inner side surface 3021 to provide air flowing passage for space convection above and below the second circuit board 51.

Please refer to FIG. 16 and FIG. 17, in this embodiment, the first side wall 3024 has a first coupling surface 30241, the second side wall 3025 has a second coupling surface 30251, the first coupling surface 30241, and the second coupling surface 30251 collectively constitutes side walls on both sides of the slot 3022. In this embodiment, the width or area of the first coupling surface 30241 is configured to be larger than the width or area of the second coupling surface 30251 (the width refers to the dimension along the width direction of the lamp tube 1). During the insertion of the second circuit board 51 into the slot 3022, the second coupling surface 30251 provides a small frictional force when it comes into contact with the second circuit board 51 due to the small width or area; and the second circuit board 51 after the slot 3022 is inserted, the first coupling surface 30241 provides better support for the second circuit board 51 due to the larger width or area, so as to improve the stability of the power supply 5 for fastening.

Please refer to FIG. 16 and FIG. 17, in this embodiment, the first side wall 3024 has a first guide surface 30242 while the second side wall 3025 has a second guide surface 30252. The first guide surface 30242 and the second guide surface 30252 together form an opening of the slot 3022 to facilitate the second circuit board 51 inserted into the slot 3022 through the opening.



## 11

Please refer to FIG. 16 and FIG. 17, in this embodiment, a limiting portion 5011 is set on an end portion of the second circuit board 51, and the bottom wall 3023 of the limiting portion 5011 is matched to restrict the movement from the second circuit board 51 in the width direction.

In specific, the limiting portion 5011 includes a notch 5111, and the bottom wall 3023 is stuck in the notch 5111, so as to restrict the movement from the second circuit board 51 in the width direction. The notch 5111 in this embodiment has a circular arc shape.

In this embodiment, the ratio of the depth of the slot 3022 to the length of the second circuit board 51 is at least 0.08 or more to improve the stability of fastening the second circuit board 51 to the slot 3022. Preferably, the ratio of the depth of the slot 3022 to the length of the second circuit board 51 is at least 0.1 or more. More preferably, the ratio of the depth of the slot 3022 to the length of the second circuit board 51 is at least 0.12 or more. The specific size of the depth of the slot 3022 in this embodiment is 2 to 5 mm.

In this embodiment, the ratio of the width of the slot 3022 to the thickness of the second circuit board 51 is 0.9:1 to 1.2:1 to achieve a proper degree of tightness. On one hand, the ratio is to prevent the circuit layer of the second circuit board 51 damaged by the card slot 3022 when the second circuit board 51 is inserted into the slot 3022. On the other hand, the ratio is to prevent the excessive space resulting in shaking of the power supply 5 when the second circuit board 51 is inserted into the slot 3022. Preferably, the ratio of the width of the slot 3022 to the thickness of the second circuit board 51 is 0.95:1 to 1.1:1. More preferably, the ratio of the width of the slot 3022 to the thickness of the second circuit board 51 is 0.95:1 to 1:1.

Please refer to FIG. 18, in this embodiment, in order to raise the withstand voltage value of the lamp cap 3, a certain straight-lined distance is maintained between the hollow conductive pin 4 and the body 301 of the lamp cap 3 through the arrangement of the insulating portion 302. Preferably, the cumulative creepage distance between the hollow conductive pin 4 and the body 301 of the lamp cap 3 is at least 4 mm in total. More preferably, the cumulative creepage distance between the hollow conductive pin 4 and the body 301 of the lamp cap 3 is at least 4.5 mm. Preferably, the cumulative creepage distance between the hollow conductive pin 4 and the body 301 of the lamp cap 3 is at least 5 mm. As shown in FIG. 18, the creepage distance between the hollow conductive pin 4 and the body 301 of the lamp cap 3 is divided into four sections of lengths a, b, c, and d, which satisfies:  $a+b+c+d \geq 4$  mm.

In this embodiment, in order to accommodate the end of the hollow conductive pin 4 in the width direction, the dimension of a is 0.5 mm to 1 mm to facilitate the installing and fastening of the hollow conductive pin 4 (the end portion of the hollow conductive pin 4 is protruding in the radial direction compared to the body of the hollow conductive pin 4).

In this embodiment, in order to accommodate the end of the hollow conductive pin 4 in the length direction, the dimension of b is 0.35 mm to 0.5 mm.

In this embodiment, the dimension of c is 1.8 mm to 3 mm to ensure the mechanical strength of the insulating portion 302.

Please refer to FIG. 18 and FIG. 19, in this embodiment, a convex portion 3026 is set on the outer edge of the insulation portion 302, and a hole 311 at the end of the body 301 substantially matches the outer contour of the insulation portion 302. By pressing the body 301 forms a groove 3012,

## 12

so that the convex portion 3026 is disposed in the groove 3012, and the insulating portion 302 is fastened.

In this embodiment, the shortest distance between the second circuit board 51 and the inner wall of the body 301 in the width direction of the lamp tube 1 is greater than 3 mm to ensure that the second circuit board 51 has a sufficient space from the body 301. Compared with the existing metal lamp cap, the existing metal lamp cap fails to effectively fasten the second circuit board 51 of the power supply 5. Therefore, the distance between the inner wall of the body 301 of the existing metal lamp cap and the second circuit board 51 cannot be fastened, which may easily result in the second circuit board 51 contacting the body of the metal lamp cap, leaving a hidden safety issue.

Please refer to FIG. 15, the lamp tube 1 in this embodiment includes a body region 102 and end region 101 respectively disposed at two ends of the body region 102. The body 21 of the lamp cap 3 is sleeved on the end region 101. The outer diameter of the tip region 101 is smaller than the outer diameter of the body region 102. The lamp cap 3 is sleeved on the end region 101, and the difference between the outer diameter of the lamp cap 3 and the outer diameter of the lamp body region 102 becomes smaller or completely flat, or the outer diameter of the lamp cap 3 is smaller than the outer diameter of the lamp body region 102. The benefit of this arrangement is that during transportation, the package support does not easily contact the lamp cap 3, so that the lamp cap 3 does not become the only stress point, and the portion where the lamp cap 3 is connected to end region 101 of the lamp tube 1 is broken due to stress concentration which improves the quality and aesthetics of the product.

In this embodiment, the first circuit board 2 is a soft circuit board or a flexible circuit board, and most areas of the first circuit board 2 (for example, more than 90% of the areas) are fastened to the inner surface of the lamp tube 1 and are not fastened to a portion of the inner surface of the lamp tube 1 to form a free portion 2001, and the free portion 2001 and the second circuit board 51 are fastened by welding. During assembly, the soldered end of the free part 2001 and the second circuit board 51 will drive the free part 51 to shrink into the interior of the lamp tube 1 and finally form an "S" or "Z" shape (viewed from the side of the lamp tube 1).

In this embodiment, the second circuit board 51 has a first surface and a second surface, wherein an electronic component 52 is installed on the first surface, and the electronic component 52 includes a capacitor, an electrolytic capacitor, a fuse, or a transformer. The distance between the portion of the first circuit board 2 attached to the inner surface of the lamp tube 1 and the second surface of the second circuit board 51 in the width direction of the lamp tube 1 is greater than 3.5 mm. To ensure that there is enough space between the two to accommodate the free portion 2001, to prevent the pins of the electronic component 52 on the second circuit board 51 from damaging the free portion 2001 of the first circuit board 2. In addition, the distance between the portion of the first circuit board 2 attached to the inner surface of the lamp tube 1 and the second surface of the second circuit board 51 in the width direction of the lamp tube 1 is less than half the diameter of the inner surface of the lamp tube 1 in order to ensure that there is sufficient space between the first surface of the second circuit board 51 and the inner surface of the lamp tube 1 to accommodate the electronic component 2.

In this embodiment, the LED tube lamp is model T8 and the outer diameter of the lamp tube 1 is around 25.4 mm.

Please refer to FIG. 20, in some embodiments, the present disclosure provides a connection structure between a power



supply **5** and a first circuit board **2**, which can be applied to an LED tube lamp, wherein the first circuit board **2** and the second circuit board **51** are connected through a connection portion. The connection portion can be a wire, a male and a female plug, and a pin. The connection portion in this embodiment adopts a third circuit board **7**, that is, the first circuit board **2** and the second circuit board **51** are connected through the third circuit board **7**, so that the light source **21** and the power supply **5** are electrically connected.

In some embodiments, the thermal conductivity of the first circuit board **2** is better than that of the third circuit board **7**. In specific, the thermal conductivity coefficient of the first circuit board **2** is higher than that of the third circuit board **7**, or during the unit time the first circuit board **2** can conduct more heat than the third circuit board **7** (assuming other conditions are the same). Therefore, the heat generated during the operation of the light source **21** can be quickly conducted to the lamp tube **1** through the first circuit board **2** and dissipated to the outside through the lamp tube **1**. In addition, the heat generated by the light source **21** is not easily conducted to the third circuit board **7**, thereby impacting the power supply **5**.

In some embodiments, the thermal conductivity of the third circuit board **7** is better than that of the second circuit board **51**. In specific, the thermal conductivity coefficient of the third circuit board **7** is higher than that of the second circuit board **51**, or during the unit time the third circuit board **7** can conduct more heat than the second circuit board **51** (assuming other conditions are the same). The electronic component **52** of the power supply **5** includes a heating element, such as a resistor, a transformer, an inductor, an IC (Integrated Circuit), etc. In order to improve the heat dissipation of the power supply **5**, at least one of the heating elements of the electronic component **52** can thermally contact the third circuit board **7** and the third circuit board **7** can thermally contact the lamp tube **1**, so that a portion of the power supply **5** can be thermally conducted to the lamp tube **1** through the third circuit board **7** for heat dissipation. In some embodiments, the heating elements of the electronic component **52** may also contact the third circuit board **7** indirectly by dissipating heat in the form of heat radiation to the third circuit board **7**.

In summary, the thermal conductivity coefficient of the first circuit board **2**, the third circuit board **7**, and the second circuit board **51** decreases in order.

In this embodiment, the hardness of the first circuit board **2** is greater than that of the third circuit board **7**. Therefore, to the first circuit board **2**, the first circuit board **2** can better carry and support the light source **21**, and as to the third circuit board **7** the foldable feature can make the first circuit board **2** and the second circuit board **51** be connected through the third circuit board **7** with more adjustable space and facilitating the connection. In this embodiment, the first circuit board **2** may be either one of a strip-shaped aluminum substrate and a glass cloth substrate (FR4).

In this embodiment, the hardness of the second circuit board **51** is greater than that of the third circuit board **7**. To the second circuit board **51**, the second circuit board **51** can better carry and support the electronic components **52** of the power supply **5**. When the power supply **5** and the third circuit board **7** are stacked, the third circuit board **7** can be bent and deformed to adapt to the power supply **5** to prevent the setting of the third circuit board **7** from affecting the normal installation of the power supply **5**.

In specific, in this embodiment, the first circuit board **2** is fastened on the inner surface of the lamp tube **1** while the third circuit board **7** is not fastened on the inner surface of

the lamp tube **1**. The third circuit board **7** may be a soft circuit board or a flexible circuit board. There are two ends disposed on the second circuit board **51** in the axial direction of the lamp tube **1** (the first end and the second end, where the first end is closer to the matching lamp cap **3**) and one end is closer to the matching lamp cap **3**, the second circuit board **51** is closer to one end of the matching lamp cap **3** and connected to one end of the third circuit board **7** while the other end of the third circuit board **7** is connected to the first circuit board **2**. During the installation and connection process, the second circuit board **51** can be inserted into the lamp tube **1** first, and connect one end of the matching lamp cap **3** closer to the second circuit board **51** to one end of the third circuit board **7**. The second circuit board **51** is closer to one end of the matching lamp cap **3** connected to one end of the third circuit board **7**. Because insertion is completed in advance, there is no need to connect the second circuit board **51** to the first circuit board **2** as in the prior art, and then insert the second circuit board **51** into the lamp tube **1** as a whole, thereby lowering the difficulty of the production process and solving the problem that the second circuit board **51** is difficult to insert in the prior art.

In this embodiment, the second circuit board **51** and the third circuit board **7** may be connected through connectors such as male and female plugs, pin headers, or the second circuit board **51** and the third circuit board **7** may be directly soldered.

Please refer to FIG. **20** and FIG. **21**, in this embodiment, the connection between the third circuit board **7** and the first circuit board **2** may be directly soldered, or adopted a male and female plug, a pin, or the like for connection. Preferably, the third circuit board **7** and the first circuit board **2** in this embodiment are connected by soldering. Specifically, there is a first pad **201** at one end of the first circuit board **2**, and there is a second pad **71** at one end of the third circuit board **7** where the first pad **201** and the second pad **71** are directly soldered (connected by soldering).

In this embodiment, the first pad **201** is spaced from the length end of the first circuit board **2** to form a connection section **202**. One end of the third circuit board **7** is placed on the connection section **202** and the second pad **71** corresponds to the first pad **201** in the length direction of the lamp tube **1**. The connecting section **202** is a part of the first circuit board **2**, and its hardness is greater than that of the third circuit board **7**. Therefore, the third circuit board **7** can better support and facilitate the connection. When the third circuit board **7** is placed on the connection section, the end of the third circuit board **7** rests on the first pad **201** (or maintain a minimum distance, such as the distance between the end of the third circuit board **7** and the first pad **201** in the length direction of the lamp tube **1** is less than 0.5 mm). At this time, the first pad **201** and the second pad **71** may be in contact with each other, or keeping smaller distance to further facilitate connection. In this embodiment, the number of the first pad **201** and the second pad **71** are three sets each, and each of them corresponds to each other. The quantity of the first pad **201** and the second pad **71** is not limited to this embodiment, and the specific quantity depends on the circuit design requirement.

In this embodiment, the first pad **201** is disposed on a side of the first circuit board **2** with the light source **21**. The second pad **71** is disposed on a side of the third circuit board **7** relatively close to a side of the electronic component **52**.

When the second circuit board **51** and the third circuit board **7** are actually connected, the ends of the second circuit board **51** and the third circuit board **7** are partially exposed outside of the lamp tube **1**, and the ends of the second circuit



board **51** and the third circuit board **7** are connected outside the lamp tube **1**. After the second circuit board **51** and the third circuit board **7** are connected, they are pushed into the lamp tube **1**. Under this premise, the third circuit board **7** is allocated a soft circuit board, so that when the second circuit board **51** and the third circuit board **7** are inserted into the lamp tube **1**, the third circuit board **7** can be bent to complete the above-mentioned actions. In this embodiment, when the third circuit board **7** is in the flat-straight state, the end portion of the third circuit board **7** at least partially extends beyond the lamp tube **1** in the axial direction of the lamp tube **1**.

In this embodiment, the second circuit board **51** and the third circuit board **7** are separated by an electronic component **52**, thereby reducing the risk of ignition caused by the second circuit board **51** contacting the third circuit board **7**. The above-mentioned electronic component **52** includes relatively large-volume components such as capacitors, transformers, and inductors to ensure a sufficient distance between the second circuit board **51** and the third circuit board **7**.

In this embodiment, in terms of the width direction of the lamp tube **1**, the second circuit board **51** and the third circuit board **7** are disposed at opposite sides of the lamp tube **1**. In other words, a central axis is in the lamp tube, and the central axis passes through the lamp tube **1** parallel to the plane of the second circuit board **51**. At this time, the second circuit board **51** and the third circuit board **7** are respectively disposed on both sides of the plane. In this way, it is ensured that the first circuit board **2** and the second circuit board **51** have a certain interval, thereby lowering the risk of fire because the first circuit board **2** contacts the second circuit board **51**.

In this embodiment, the thickness of the third circuit board **7** is smaller than the thickness of the second circuit board **51**. When the power supply **5** and the third circuit board **7** are stacked and the inner diameter of the lamp tube **1** is the same, controlling the thickness of the third circuit board **7** can provide more space for the power supply **5** to facilitate the power supply **5** to more easily select and arrange the electronic components **52**. In this embodiment, the thickness of the third circuit board **7** is also smaller than the thickness of the first circuit board **2**.

Please refer to FIG. **22**, in some embodiments, an LED tube lamp which the basic structure is the same as the LED tube lamp of the previous embodiments, except that the first circuit board **2** is fastened on the inner surface of the lamp tube **1** while the third circuit board **7** is not fastened on the inner surface of the lamp tube **1**. The third circuit board **7** may be a soft circuit board or a flexible circuit board.

There are a first end and a second end on the second circuit board **51** in the axial direction of the lamp tube **1**, wherein the first end is closer to the matched lamp cap **3**, and the second end of the second circuit board **51** is connected to the third circuit board **7** while the other end of the third circuit board **7** is connected to the first circuit board **2**. During the assembly and connection process, the second circuit board **51** is completely exposed outside of the lamp tube **1**, so that the second end thereof is exposed outside of the lamp tube **1**, and the end of the third circuit board **7** is exposed outside of the lamp tube **1**, thereby facilitating the second end of the second circuit board **51** connected to the end of the third circuit board **7**. After the connection is completed, the second circuit board **51** is pushed into the lamp tube **1**. In this embodiment the second circuit board **51** and the third circuit board **7** may be connected through male

and female plugs and pin header connectors, or the second circuit board **51** and the third circuit board **7** may be directly soldered together.

Please refer to FIG. **23** to FIG. **29**, in some embodiments, a connection method between a power supply **5** and a hollow conductive pin **4** is disclosed. The LED tube lamp in these embodiments includes a connecting wire **8**, and the hollow conductive pin **4** is fastened on the lamp cap **3**. One end of the connecting wire **8** is electrically connected to the hollow conductive pin **4** (the connecting wire **8** and the hollow conductive pin **4** are electrically connected through contact), the other end of the connecting wire **8** is connected to the second circuit board **51**, and the connecting wire **8** is configured to reach a certain degree of the temperature when fusing occurs (for instance when the temperature reaches 300° C.), that is, when the LED tube lamp operates and arcing occurs, and reaching a certain temperature, the connecting wire **8** will be blown to protect from the over-heated problem, in order to prevent the LED tube lamp from further danger due to inflammation. In order to achieve the above purpose, the connecting wire **8** may include a fusible portion **81**, and the fusible portion **81** may use a low melting point conductive material to reach the connecting wire **8** at a certain temperature (when the melting point of the fusible portion **81** is reached), The purpose of fusing is to disconnect the connecting wire **8**. The fusible portion **81** may be a low-melting alloy (such as a melting point lower than 300° C.) such as bismuth, cadmium, tin, lead, thallium, or indium, or the above-mentioned elements or a combination thereof as a main component. In addition, the low-melting-point materials of the above elements or combinations thereof can be configured to have different melting points, so the materials can be specifically selected according to actual needs.

In some embodiments, the melting point of the fusible portion **81** is less than or equal to that of any electronic component on the second circuit board **51**, the second circuit board **51** itself or the electronic component used to connect the second circuit board **51** with the second circuit board **51**. From another perspective, the melting point of the fusible portion **81** is less than or equal to the melting point of any conductive substance on the second circuit board **51**. In order to ensure when the temperature is too high, the fusible portion **81** is first disconnected to avoid a condition in which the conductive material on the second circuit board **51** is melted and a short circuit or even a fire occurs on the second circuit board **51**.

As shown in FIG. **23**, in this embodiment, the entire connecting wire **8** is composed of a fusible portion **81**, that is, the entire connecting wire **8** is made of a low-melting conductive material. In some embodiments, the connecting wire **8** may only include a part of the fusible portion **81** (described in FIG. **13**). When the cost of the material of the fused portion **81** is high (compared to the connecting wire **8**), this method can reduce the cost. In this embodiment the melting point of the fusible portion **81** is lower than the melting point of the remaining portions of the connecting wire **8**.

In some embodiments, if the second circuit board **51** and the first circuit board **2** are connected through a connecting wire **8**, the connecting wire **8** is used to connect the second circuit board **51** and the first circuit board **2** may also adopt the above technical solution, that is, the connecting wire **8** includes fusible portion **81**. In order to achieve the result of arc protection (over-heated protection).

As shown in FIG. **23**, in order to prevent the fusible portion **81** of the two connecting wires **8** from being short-circuited due to contact after the fusible portion **81** is



melted. The following installations can be made: the distance between the two hollow conductive pins **4** is **L1**, and the length **L2** of the fusible portion **81** of the connecting wire **8** is set to be shorter than the distance of the two hollow conductive pins **4** is **L1**. Therefore, when the two hollow conductive pins **4** are set up and down, even if the fusible portion **81** is melted and one end is separated from the second circuit board **51**, when the fusible portion **81** is bent due to gravity, it cannot contact the lower connecting wire **8** due to its length. As shown in FIG. 27, a schematic diagram shows the upper fusible portion **81** is bent downward. As shown in FIG. 29, if the entire connecting wire **8** is composed of a fusible portion **81**, the length **L2** of the fusible portion **81** is calculated as a portion of the connecting wire **8** exposed outside the hollow conductive pin **4**.

In some extreme cases, the fusible portion **81** is melted and one end is separated from the second circuit board **51**. The fusible portion **81** is bent due to gravity, and the fusible portions **81** of the two connecting wires **8** are relatively bent at the same time. The length **L2** of the fusible portion **81** is set to be less than half of the distance **L1** of the two hollow conductive pins **4**, that is, even if the two fusible portions **81** are relatively bent, a short circuit does not occur. As shown in FIG. 28, a schematic diagram shows the two fusible portions **81** are relatively bent.

As shown in FIG. 26, the connection of the connecting wire **8** and the second circuit board **51** is shown. An adsorption portion **514** is disposed on the second circuit board **51**, and one end of the fusible portion **81** of the connecting wire **8** is electrically connected to the adsorption portion **514**. The adsorption portion **514** is a conductive material. After the fusible part **81** is connected to the end of the adsorption part **514** and is melted, the adsorption part **514** can adsorb and gather the material of the melted fusible part **81** to prevent the fusible part **81** from flowing to other places and cause a short circuit, and so on. When the fusible portion **81** is made of tin or mainly tin, the adsorption portion **514** is a metal material, particularly copper, and has the function of adsorbing and gathering the fusible portion **81**. The melting point of the adsorption portion **514** is higher than the melting point of the fusible portion **81**.

Please refer to FIG. 24, a schematic diagram of a circuit board of an LED tube lamp according to an embodiment is shown. The circuit board in this embodiment includes at least two connecting portions **91** and the two connecting portions **91** are electrically connected (electrically connected). Specifically, the connecting portions **91** are connected to each other through the connection unit **92**. The connection unit **92** includes a fusible portion **921**. When an arc is drawn near the connecting portion **91** or the temperature is too high, the fusible portion **921** causes the connecting portion **91** to melt. The electrical connection is then broken. The fusible portion **921** may use a low-melting conductive material (melting point is lower than 300° C.) to achieve the purpose of the connection unit **92** to fuse at the fusible portion **921** at a certain temperature, so that the connection unit **92** is disconnected and the two connecting portions **91** are disconnected. An open circuit is formed to protect it (arc protection, over-heated protection). Compared with the prior art, two wires are used to connect the two connecting portions or copper wires are used to connect the two connecting portions, and therefore improves safety. The fusible portion **921** may be a low-melting alloy (having a melting point below 300° C.) such as bismuth, cadmium, tin, lead, thallium, or indium, or the above elements or a combination thereof as a main component. And the low melting point materials of the above elements or combina-

tions thereof have different melting points, so they can be selected according to actual needs.

In this embodiment, the connection unit **92** may be composed of only the fusible portion **921**. In some embodiments, the connection unit **92** includes only a part of the fusible portion **921**. When the cost of the material the fusible portion **921** is high, this method can reduce the cost.

In this embodiment, the circuit board may be the second circuit board **51** or the first circuit board **2** described above, or may be another component having a connecting portion.

As shown in FIG. 25, in this embodiment, an adsorption unit **93** may be further provided between the two connecting portions **91**. The fusible portion **921** at least partially contacts the adsorption unit **93**. After the fusible portion **921** is melted, the adsorption unit **93** adsorbs the fusible portion **921**, so the materials of the melting portion **921** are melted to ensure that after the melting portion **921** is melted, the melting portion **921** is broken due to the adsorption effect of the adsorption unit **93**. For example, when the fusible portion **921** is made of tin or mainly tin, the adsorption unit **93** is made of a material that can easily absorb tin, such as a metal material, especially copper. Alternatively, the adsorbing unit **93** is made of the same material as the connecting portion **91** to achieve the function of adsorbing the material after the melting portion **921** is melted.

In this embodiment, the melting point of the fusible portion **921** is less than or equal to the melting point of any electronic component on the circuit board, the circuit board itself, or the electronic component used to connect the circuit board with the circuit board. From another perspective, the melting point of the fusible portion **921** is less than or equal to the melting point of any conductive substance on the circuit board. In order to ensure that the temperature is too high, the fusible portion **921** is first broken off to avoid a situation where a conductive material on the circuit board is melted and a short circuit or even a fire occurs on the circuit board.

Preferably, in this embodiment, the melting points of the materials of the connecting portion **91**, the adsorption unit **93**, and the circuit board corresponding to the fusible portion **921** is higher than the fusible portion **921**, so as to ensure that the connecting portion **91**, the adsorption unit **93**, and the circuit board will not melt before the fusible portion **921** melts.

While the preferred embodiment of the invention has been set forth for the purpose of disclosure, modifications of the disclosed embodiment of the invention as well as other embodiments thereof may occur to those skilled in the art. Accordingly, the appended claims are intended to cover all embodiments which do not depart from the spirit and scope of the invention. The disclosure of all articles and references, including patent applications and publications, is hereby incorporated by reference for all purposes. The omission of any aspect of the subject matter disclosed herein in the preceding claims is not intended to abandon the subject matter, nor should the inventor be considered to have considered the subject matter as part of the disclosed subject matter.

What is claimed is:

1. An LED tube lamp, comprising:
  - a lamp tube;
  - a first circuit board, disposed in the lamp tube, having a plurality of light sources mounted thereon;
  - two lamp caps disposed at respective ends of the lamp tube;



## 19

a power supply substantially disposed in one or both of the two lamp caps, the power supply having a second circuit board; and

a connection structure having a third circuit board, the third circuit board for connecting the first circuit board to the second circuit board thereby connecting the light sources to the power supply.

2. The LED tube lamp of claim 1, wherein the thermal conductivity of the first circuit board is higher than that of the third circuit board.

3. The LED tube lamp of claim 1, wherein the thermal conductivity of the third circuit board is higher than that of the second circuit board.

4. The LED tube lamp of claim 3, wherein the power supply includes an electronic component, the electronic component of the power supply includes one or more heating elements, at least one of the heating elements of the electronic component thermally contacts to the third circuit board.

5. The LED tube lamp of claim 3, wherein the power supply includes an electronic component, the electronic component of the power supply includes a heating element, the heating element for dissipating heat in the form of heat radiation to the third circuit board.

6. The LED tube lamp of claim 1, wherein the hardness of the first circuit board is greater than that of the third circuit board.

7. The LED tube lamp of claim 1, wherein the hardness of the second circuit board is greater than that of the third circuit board, the power supply and the third circuit board are stacked, and the third circuit board is bent and deformed to adapt to the power supply.

8. The LED tube lamp of claim 1, wherein the first circuit board is fastened on the inner surface of the lamp tube while the third circuit board is not fastened on the inner surface of the lamp tube, and the third circuit board is a soft circuit board or a flexible circuit board.

9. The LED tube lamp of claim 1, wherein the second circuit board has a first end and a second end in a axial direction of the lamp tube, and the first end of the second circuit board is closer to the matching lamp cap, the first end of the second circuit board is connected to one end of the third circuit board while the other end of the third circuit board is connected to the first circuit board.

10. The LED tube lamp of claim 9, wherein the second circuit board is directly soldered to the third circuit board.

## 20

11. The LED tube lamp of claim 10, wherein the first circuit board has a first pad, and the third circuit board has a second pad, the first circuit board and the third circuit board are directly soldered through the first pad and the second pad.

12. The LED tube lamp of claim 11, wherein the first pad of the first circuit board is spaced from the end of the first circuit board in a longitudinal direction to form a connection section, one end of the third circuit board is placed on the connection section and the second pad of the third circuit board corresponds to the first pad of the first circuit board in the length direction of the lamp tube.

13. The LED tube lamp of claim 12, wherein the connection section is a part of the first circuit board, and the hardness of the connection section is higher than that of the third circuit board.

14. The LED tube lamp of claim 11, wherein the power supply includes an electronic component, the first pad of the first circuit board is disposed on a side of the first circuit board with the light sources, and the second pad of the third circuit board is disposed on a side of the third circuit board relatively close to a side of the electronic component.

15. The LED tube lamp of claim 1, wherein the second circuit board and the third circuit board are separated by the electronic component.

16. The LED tube lamp of claim 15, wherein the electronic component includes one of a capacitor, transformer or inductor.

17. The LED tube lamp of claim 1, wherein the second circuit board and the third circuit board are disposed at opposite sides in the width direction of the lamp tube.

18. The LED tube lamp of claim 1, wherein the thickness of the third circuit board is smaller than that of the second circuit board.

19. The LED tube lamp of claim 1, wherein a hollow conductive pin is arranged on the lamp cap, the LED tube lamp includes a connecting wire, and the hollow conductive pin is fastened on the lamp cap, one end of the connecting wire is electrically connected to the hollow conductive pin, the other end of the connecting wire is connected to the second circuit board, the connecting wire includes a fusible portion and the fusible portion is a low-melting alloy.

20. The LED tube lamp of claim 19, wherein the melting point of the fusible portion is less than or equal to the melting point of any conductive substance on the second circuit board.

\* \* \* \* \*